

Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

Lecture-27

Finalizing Design including the Sizes of the Keys

Outline of the Lecture

- **Design Verification of Selected Keys**
- **Comments on All Shaft Subassembly**

Viewing the Reduction Gear Unit for Load Analysis and Shaft Design Verification (Recapitulation) :

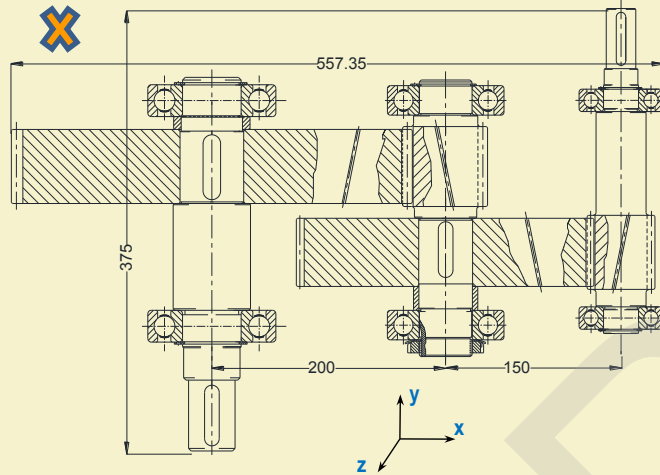


Fig. 1: Plan View (xz Plane) of the Gear unit in Earlier Lectures (Ref: Slide 9, lecture-23)

ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

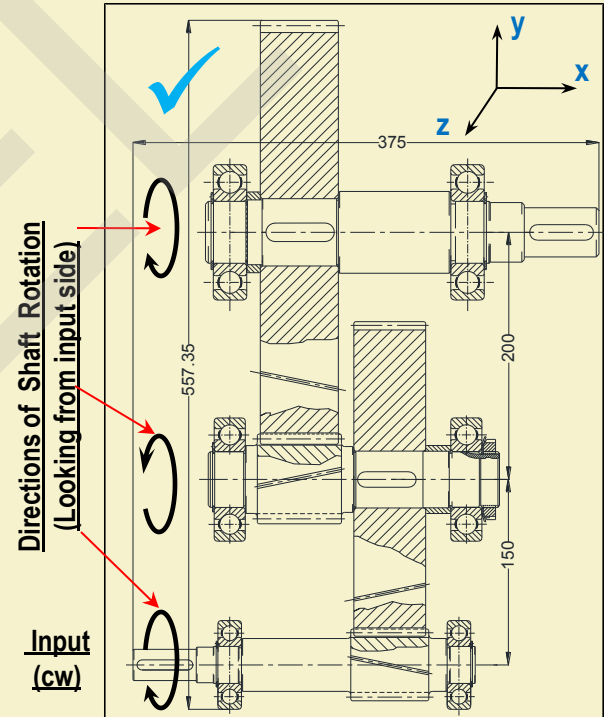
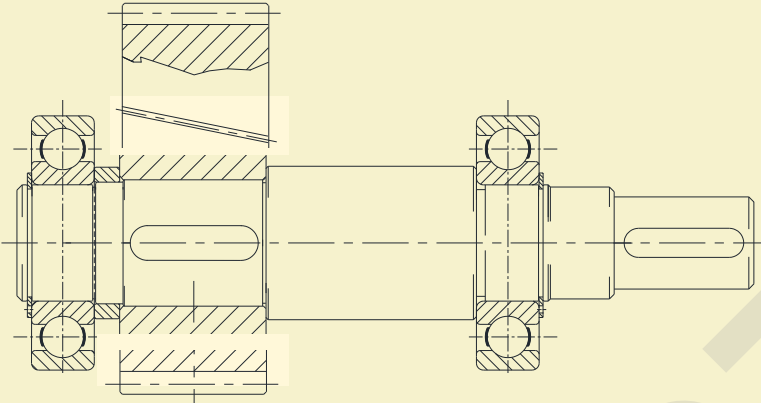
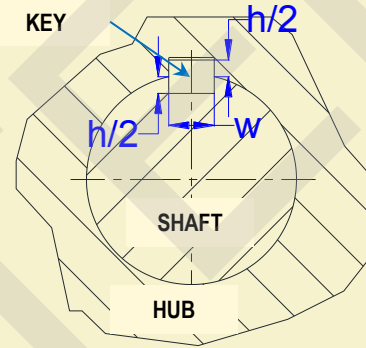
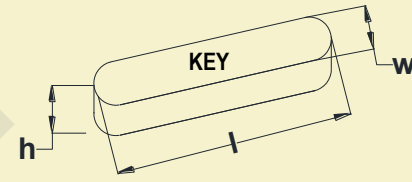


Fig.- 2 : Plan View of the Reduction Gear unit (Only subassemblies of three shafts) (in xz plane- the plane of slide)

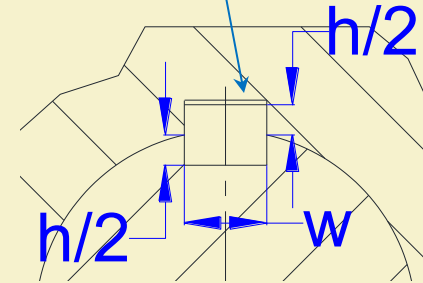
Verification of the strength of the selected keys :



Output Shaft Sub Assembly



Note the Gap

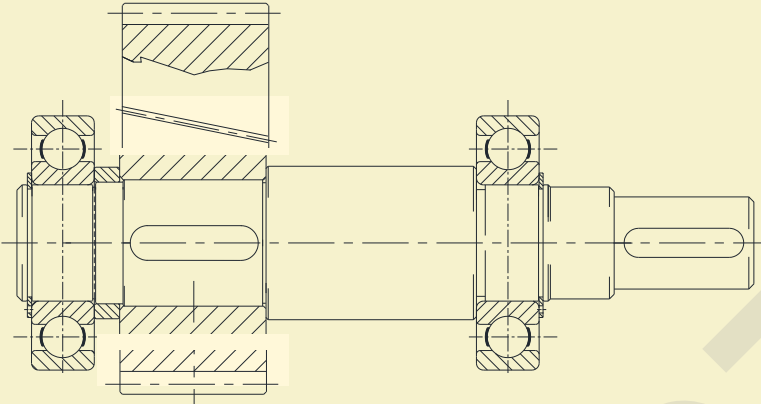


For all shafts the chosen keys are standard rectangular keys. All key ways are cut by end mill key slot cutter.

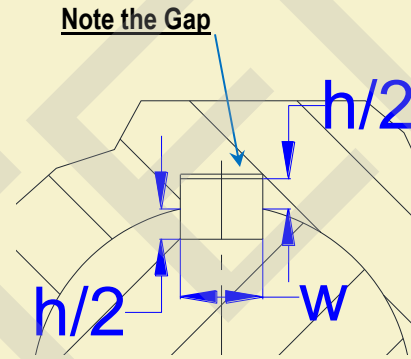
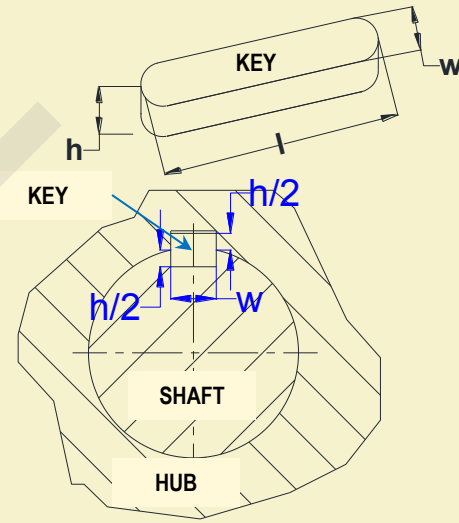
Keys are made of low to medium carbon steel (C30 – an example). It is made weaker than shaft and mating parts material.

ALL DIMENSIONS ARE IN MM
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Verification of the strength of the selected keys :



Output Shaft Sub Assembly



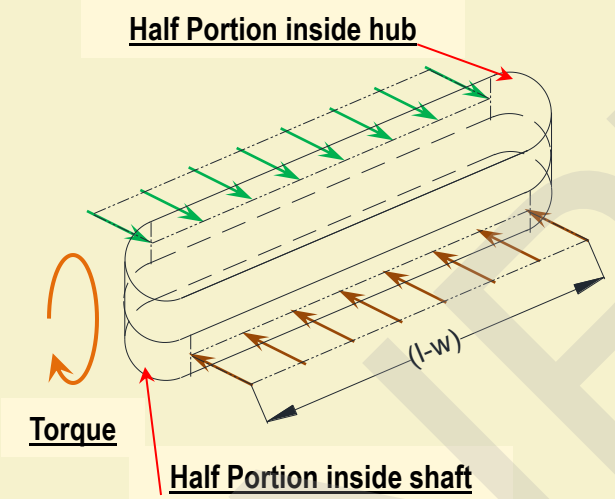
Keyway is milled by 'End mill cutter' (Specially made for key slot cutting). However, at the free end 'Side and face cutter' can be used. For gear (or say coupling)hub slotting is done to generate key ways. (For spline broaching is used.)

ALL DIMENSIONS ARE IN MM
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Failure of keys :

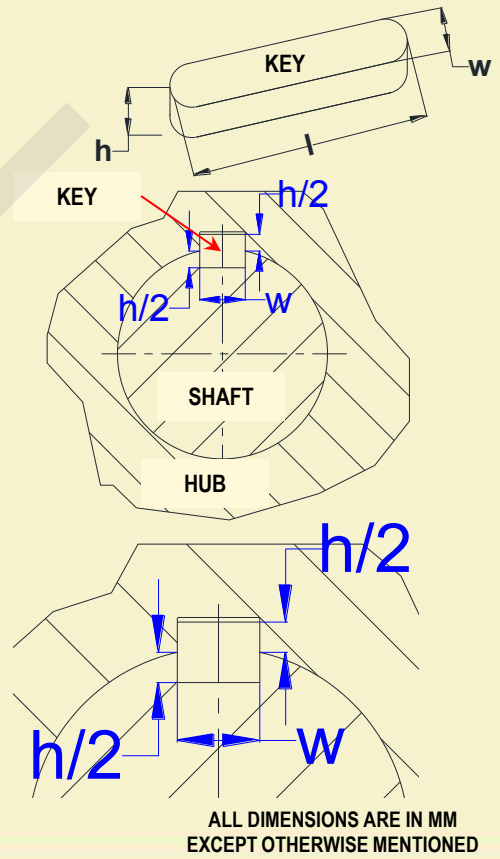
The keyways are made in such a way the half of the key height (h) sits in shaft and other half in hub.

Therefore, in torque transmission the forces acting on a key are as follows:



The net force due to torque transmission:

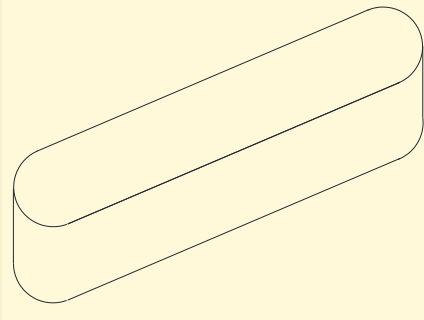
$$F_k = \text{Torque} / \text{Shaft radius}$$
$$= \frac{2T}{d_s}$$



Failure of keys (contd...) :

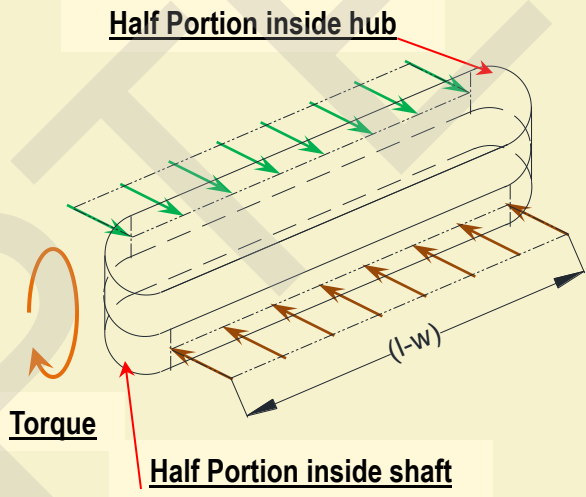
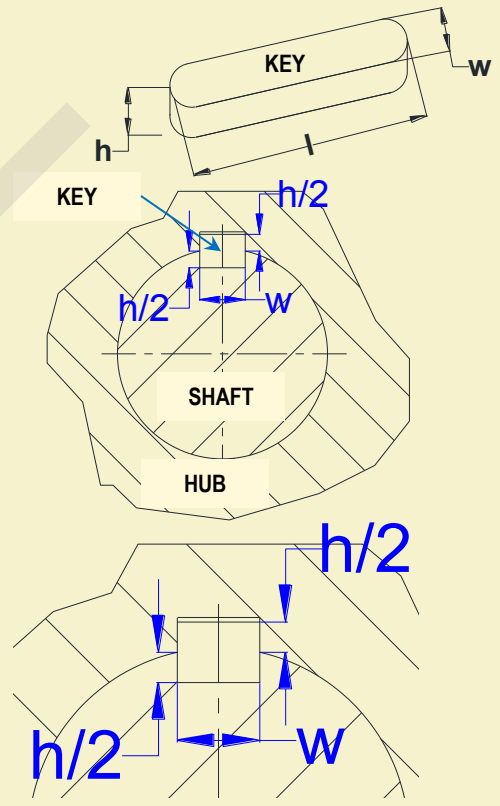
(i) Failure due to shear:

If the developed shear stress (τ_k) exceeds the allowable shear strength (S_{allow}) of the key material:



Shear stress:

$$\tau_k = \frac{F_k}{(l - w) \times w + (\pi \times w^2 / 4)}$$

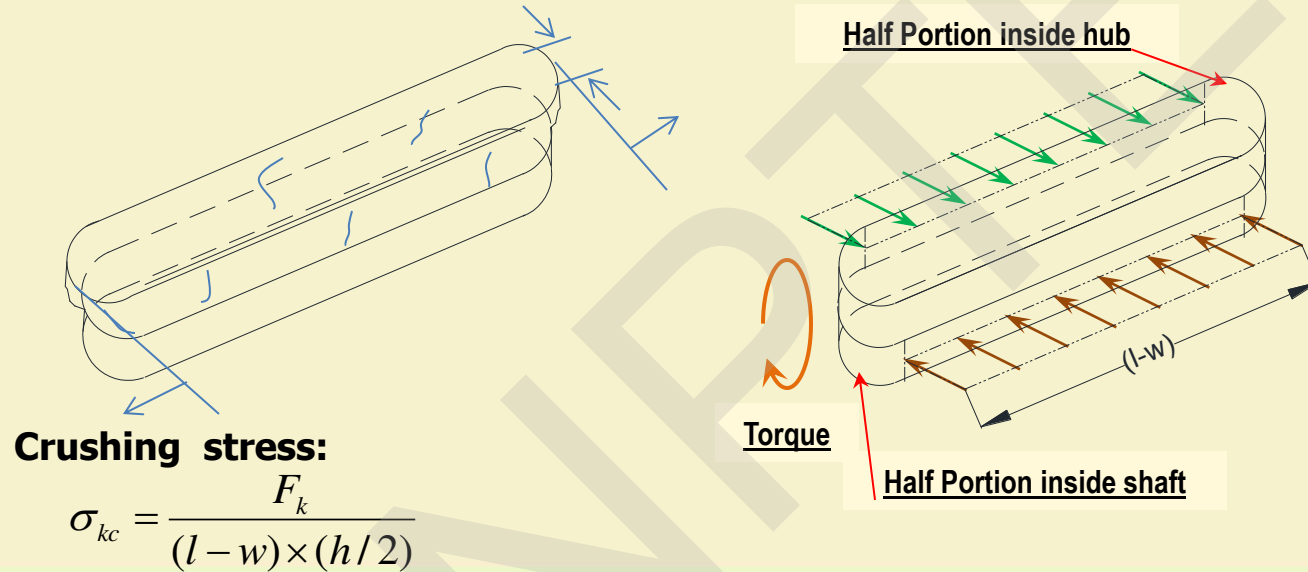
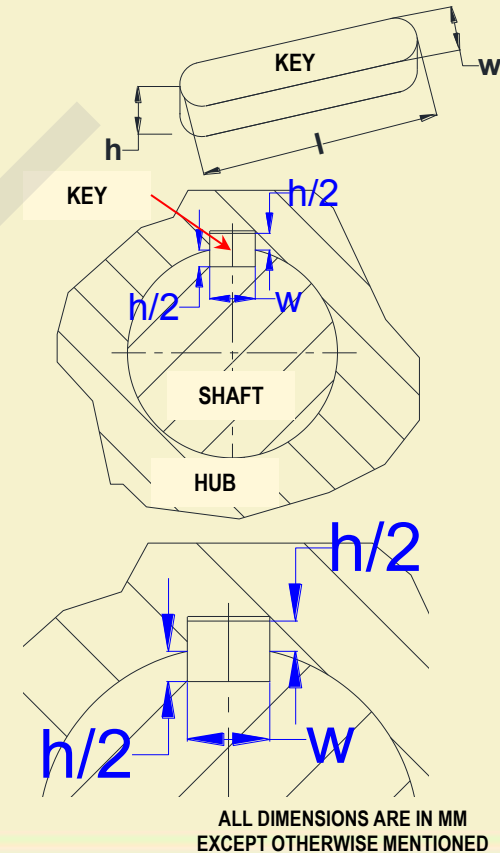


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Failure of keys (contd...) :

(ii) Failure due to crushing:

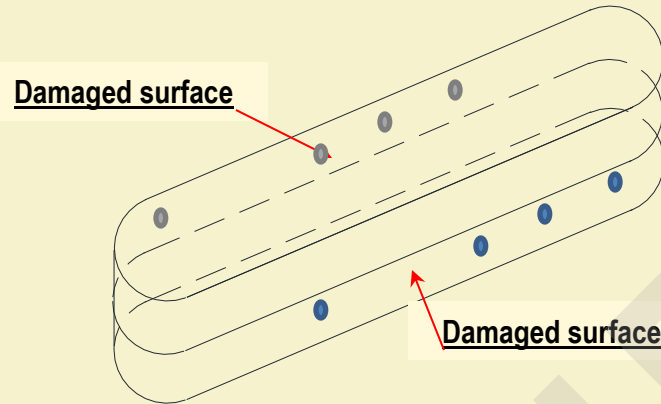
If the developed crushing stress (σ_{kc}) exceeds the allowable crushing strength (S_{cka}) of the key material:



Failure of keys (contd...) :

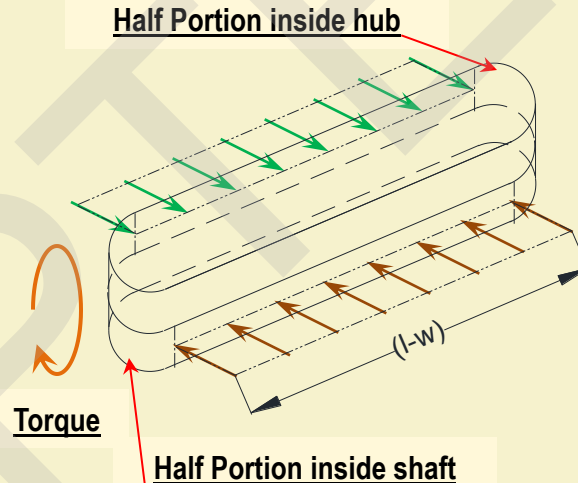
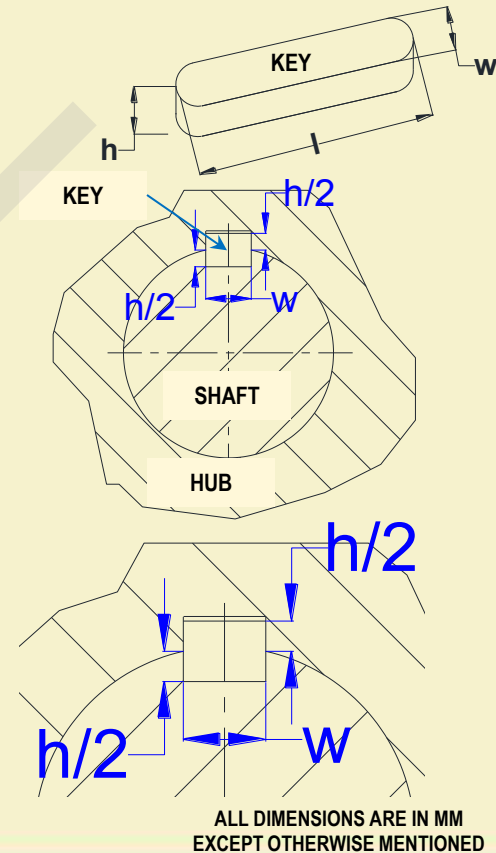
(iii) Bearing strength Failure :

If the developed bearing (surface contact) stress (σ_{kc}) exceeds the allowable bearing strength (S_{bka}) of the key material:

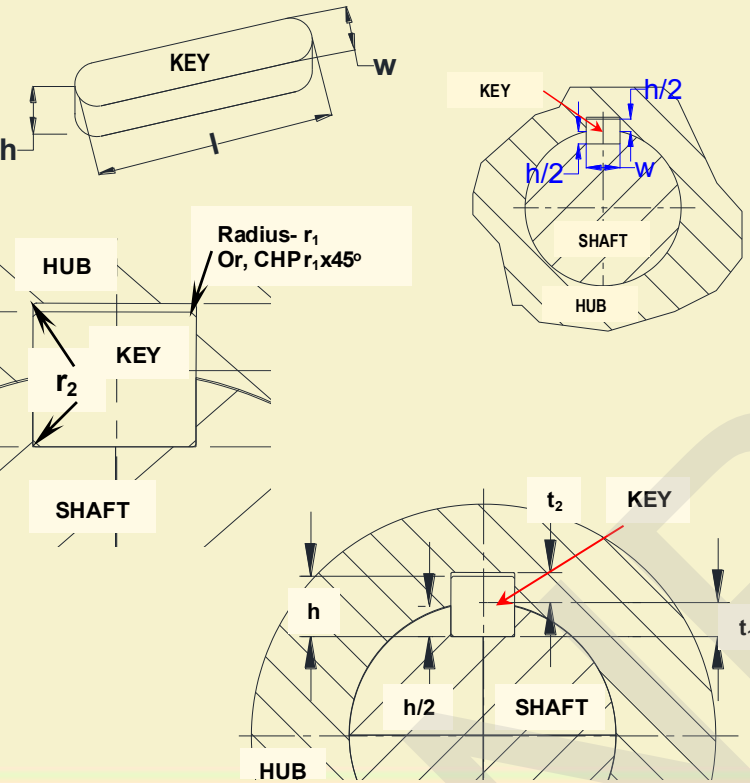


Bearing stress (pressure):

$$\sigma_{kb} = \frac{F_k}{(l - w) \times (h/2)}$$



Dimensions of Parallel Keys (Round Ends) and Keyways (Sample) :

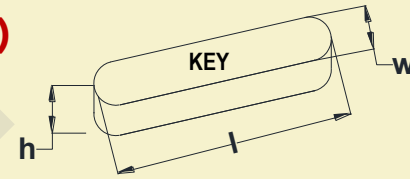
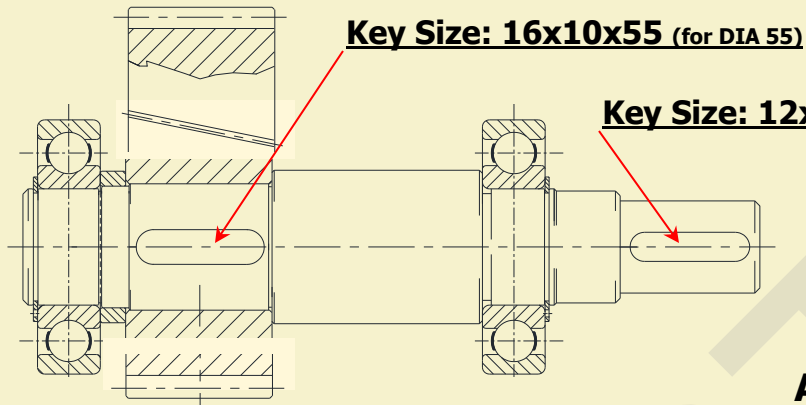


For Shaft Diameter	From Up to	17 22	22 30	30 38	38 44	44 50	50 58	58 65
Key Cross Section	Width w Height h	6	8	10	12	14	16	18
		6	7	8	8	9	10	11
Keyway depth (nominal)	In shaft t_1	3.5	4	5	5	5.5	6	7
	In hub t_2	2.8	3.3	3.3	3.3	3.8	4.3	4.4
Tolerances on Keyway depth	t_1	+0.2						
	t_2	+0.1			+0.2			
Chamfer or radius at key edges	r_1 max	0.35			0.55			
	r_1 min	0.25			0.40			
Keyway corner radius	r_2 max	0.25			0.40			
Length of Key l	l min	14	18	22	28	36	45	50
	l max	70	90	110	140	160	180	200

These keys are designated as : Parallel Key (round ends) (w x h x l) IS:2048-1962

Verification of the strength of the selected keys :

(Output Shaft)



Output Shaft Sub Assembly

Let the key material be C30

For which (Considering a factor of safety of 2 and Shear strength is half of the Yield Strength.)

Allowable Shear Strength $S_{ska} = 50 \text{ MPa}$

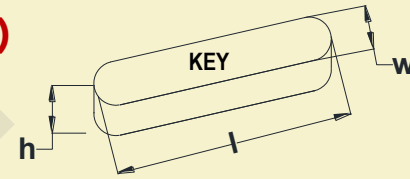
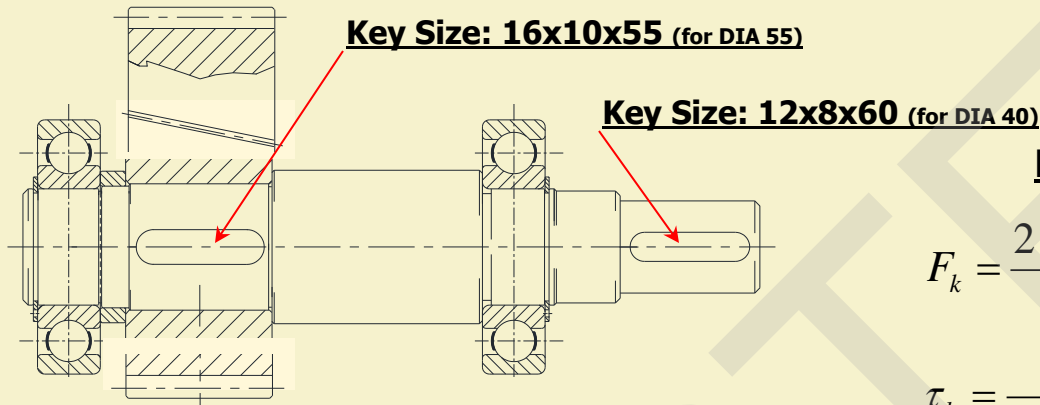
Allowable Crushing strength $S_{cka} = 120 \text{ MPa}$

Allowable bearing strength (S_{bka}) is usually higher than crushing strength.

ALL DIMENSIONS ARE IN MM
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Verification of the strength of the selected keys :

(Output Shaft)



Output Shaft Sub Assembly

Allowable Shear Strength $S_{ska} = 50 \text{ MPa}$

Key at Output End

$$F_k = \frac{2 \times (30 \times 24.42)}{0.04} \text{ N} = 36630 \text{ N}$$

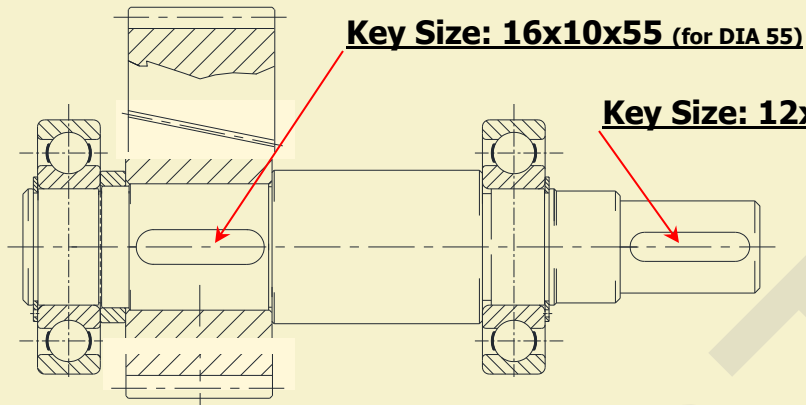
$$\begin{aligned} \tau_k &= \frac{F_k}{(l - w) \times w + (\pi \times w^2 / 4)} \\ &= \frac{36630}{(0.060 - 0.012) \times 0.012 + (\pi \times 0.012^2 / 4)} \\ &= \frac{36630}{6.9 \times 10^{-4}} = 53.2 \times 10^6 \text{ Pas} = 53.2 \text{ MPa} \end{aligned}$$

It is slightly more than allowable Shear Strength . However, it is acceptable.

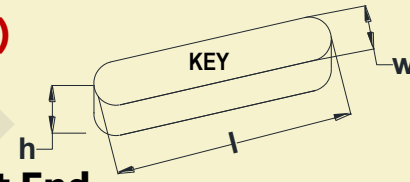
ALL DIMENSIONS ARE IN MM
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Verification of the strength of the selected keys :

(Output Shaft)



Output Shaft Sub Assembly



Key at Output End

Crushing stress:

$$\begin{aligned}\sigma_{kc} &= \frac{F_k}{(l - w) \times (h / 2)} \\ &= \frac{36630}{(0.060 - 0.012) \times (0.008 / 2)} = \frac{36630}{1.92 \times 10^{-4}} \\ &= 190.8 \times 10^6 \text{ Pas} = 190.8 \text{ MPa}\end{aligned}$$

Allowable Crushing strength $S_{cka} = 120 \text{ MPa}$

It is higher than allowable Crushing Strength .

Therefore, the key material finally chosen C40 (Shaft C45 and pre machining heat treated):

Allowable Shear Strength $S_{ska} = 70 \text{ MPa}$

Allowable Crushing strength $S_{cka} = 200 \text{ MPa}$

Similarly, all other keys are verified for their strengths.

ALL DIMENSIONS ARE IN MM
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Comments on the Design before finalizing the design for complete drawing:

All pinions, gears and shafts are satisfactorily designed. However, the Output Shaft material is finally taken as C45 and pre machining heat treated. Keys are made of C40.

For all shaft support bearings can be taken of lower size and or from lower series.



Thank You



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Prof. Rathindranath Maiti
Mechanical Engineering Department

Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

Lecture-28

Development of Plan & Elevation of Gear Reduction Unit- I

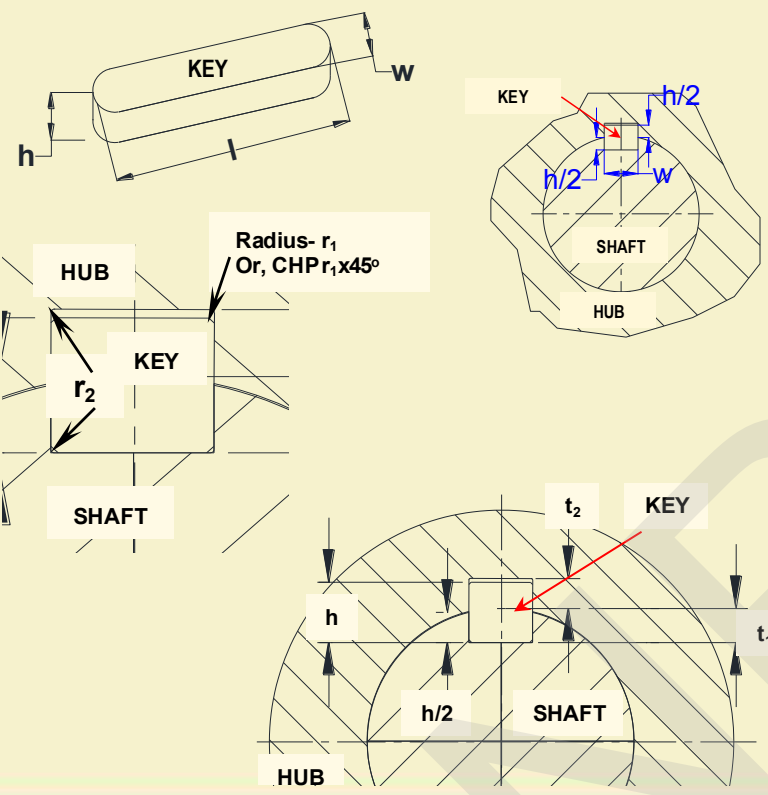


Outline of the Lecture

- **Design Verification of Selected Keys**
- **Comments on General Layout Developed so far**
- **Development of Plan and Elevation of the Reduction Gear Unit- I**



Dimensions of Parallel Keys (Round Ends) and Keyways (Sample) :



For Shaft Diameter	From Up to	17 22	22 30	30 38	38 44	44 50	50 58	58 65
Key Cross Section	Width w Height h	6	8	10	12	14	16	18
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Keyway depth (nominal)	In shaft t_1	3.5	4	5	5	5.5	6	7
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Length of Key l	l min	14	18	22	28	36	45	50
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ALL DIMENSIONS ARE IN MM EXCEPT OTHERWISE MENTIONED								
These keys are designated as : Parallel Key (round ends) (w x h x l) IS:2048-1962								

Strength of Selected Parallel Keys (Round Ends) – Design Verification:

Input Shaft Key(S)

Input Shaft- Input End ($\Phi 30$ mm) : Parallel Round End Key – 8x7x45

Nominal Input Shaft Torque – 30 Nm

Therefore, Nominal force on key:
$$F_{kni} = \frac{2 \times 30}{0.03} = 2000N$$

Considering severity of medium shock load a factor of Safety $f_k = 1.5$ is considered in key strength calculation:

Therefore, forces on key:
$$F_k = 1.5 \times F_{kni} = 3000N$$

and, developed stresses : Shear $\tau_k = 8.625\text{MPa}$, Crushing $\sigma_{kc} = 23.25\text{MPa}$

Earlier decision : All Keys are made of C40

However for Input Shaft Key MS (C20) is taken.

ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Strength of Selected Parallel Keys (Round Ends) – Design Verification (contd....) :

Intermediate Shaft Key(S)

Intermediate Shaft- 1st. Stage Gear Mounting (Φ 46.5 mm) :

Parallel Round End Key – 14x9x50

Nominal Torque at Intermediate Shaft – $30 \times (81/17) = 143 \text{ Nm}$

Therefore, Nominal force on key:

$$F_{kn} = \frac{2 \times 143}{0.0465} = 6148 \text{ N}$$

Considering a factor of Safety $f_k = 1.5$

Therefore, forces on key:

$$F_k = 1.5 \times F_{kn} = 9222 \text{ N}$$

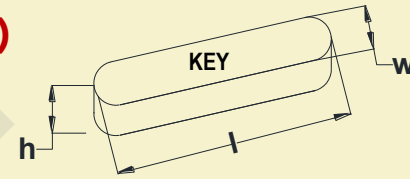
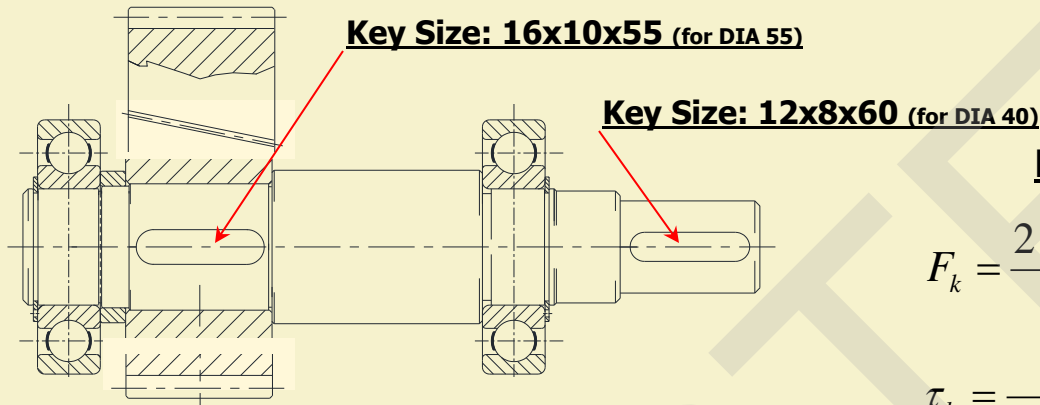
and, developed stresses : Shear $\tau_k = 14 \text{ MPa}$, Crushing $\sigma_{kc} = 57 \text{ MPa}$.

Also For Intermediate Shaft Key MS (C20) is taken.

ALL DIMENSIONS ARE IN MM
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Verification of the strength of the selected keys :

(Output Shaft)



Output Shaft Sub Assembly

Key at Output End

$$F_k = \frac{2 \times (30 \times 24.42)}{0.04} N = 36630 N$$

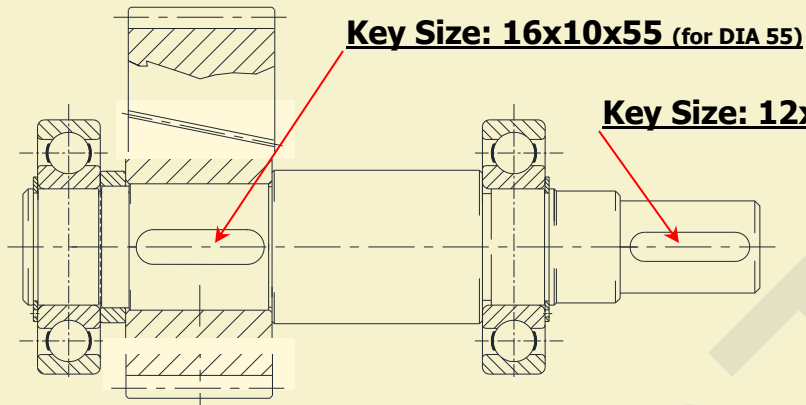
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Multiplying by a factor of safety of 1.5 developed shear stress is 106.4 MPa.

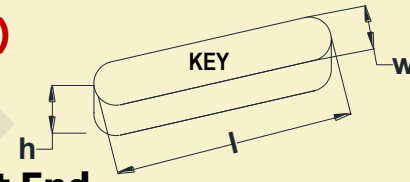
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Verification of the strength of the selected keys :

(Output Shaft)



Output Shaft Sub Assembly



Key at Output End

Crushing stress:

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Allowable Crushing strength $S_{cka} = 120 \text{ MPa}$

It is higher than allowable Crushing Strength .

Therefore, the key material finally chosen C40 (Shaft C45 and pre machining heat treated):

Allowable Shear Strength $S_{ska} = 70 \text{ MPa}$

Allowable Crushing strength $S_{cka} = 200 \text{ MPa}$

Similarly, all other keys are verified for their strengths.

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Comments on the Design before finalizing the design for complete drawing:

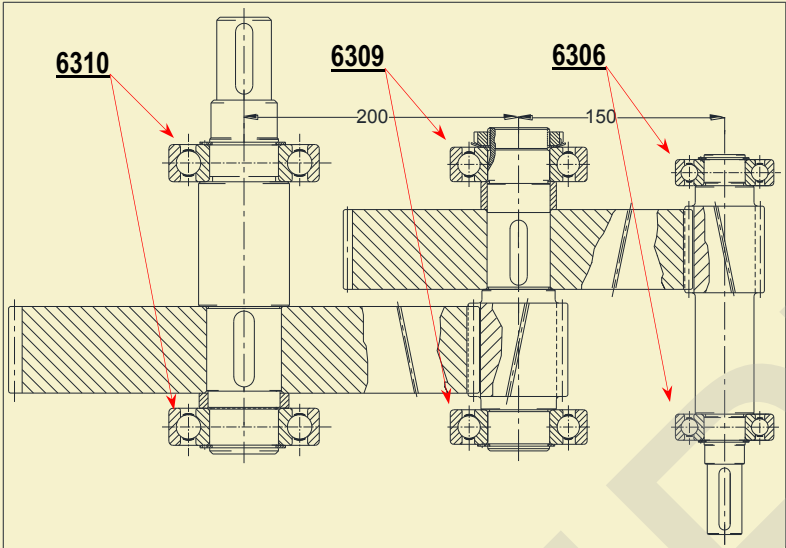
All pinions, gears and shafts are satisfactorily designed. However, the Output Shaft material is finally taken as C45 and pre machining heat treated. Keys are made of C40.

For all shaft support bearings can be taken of lower size and or from lower series.

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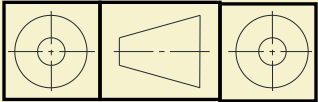
Development of Plan and Elevation of Assembled Gear Reduction Unit:



**Plan View of the Reduction Gear unit
(Only subassemblies of three shafts)
(in the plane of slide)**

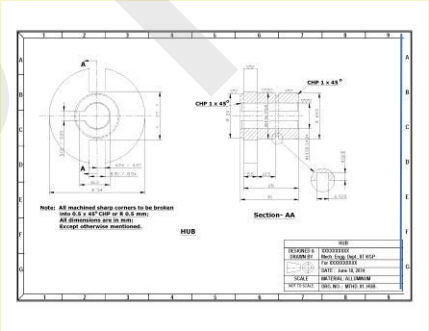
	Milimeter		Inches	
	Height	Width	Height	Width
A0	1189	841	46.8	33.1
A1	841	594	33.1	23.4
A2	594	420	23.4	16.5
A3	420	297	16.5	11.7
A4	297	210	11.7	8.3
A5	210	148	8.3	5.8
A6	148	105	5.8	4.1
A7	105	74	4.1	2.9
A8	74	52	2.9	2.1

Standard Drawing Sheet Sizes



Angle of Projection

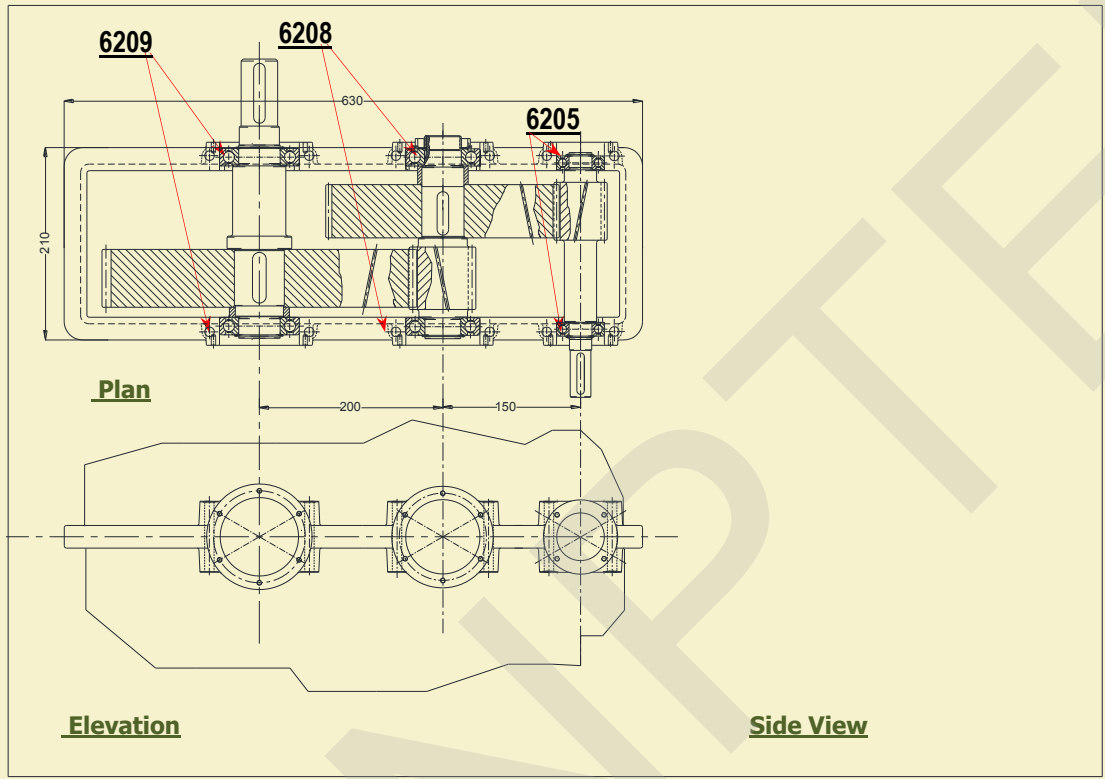
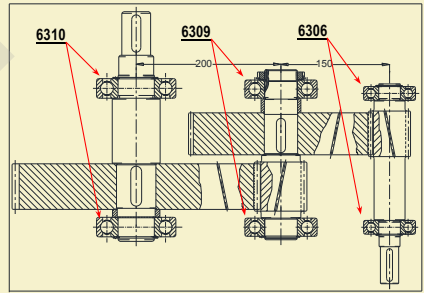
Scale : 1:1, 1:2, 1:2.5, 1:5, 1:10



Typical Drawing

ALL DIMENSIONS ARE IN MM
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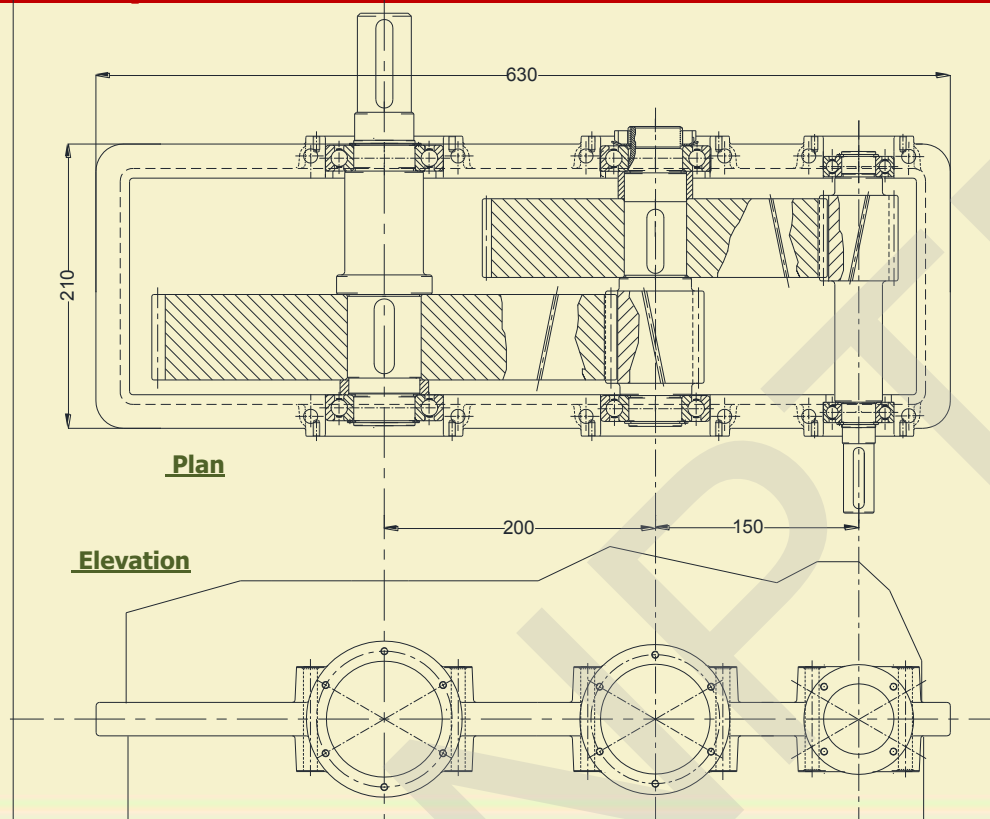
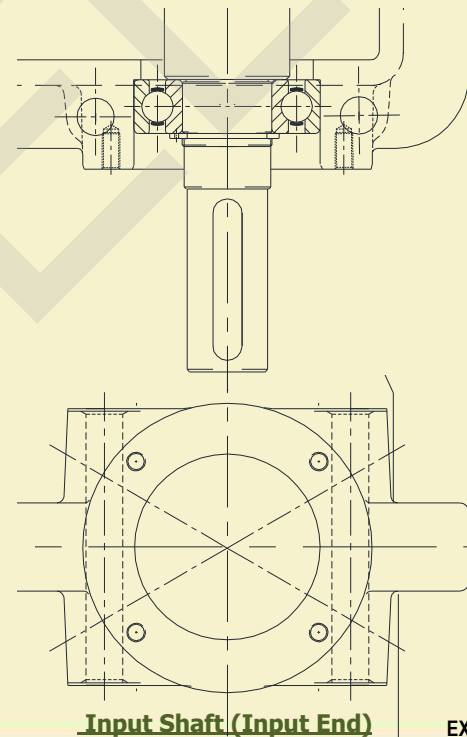
Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Plan View

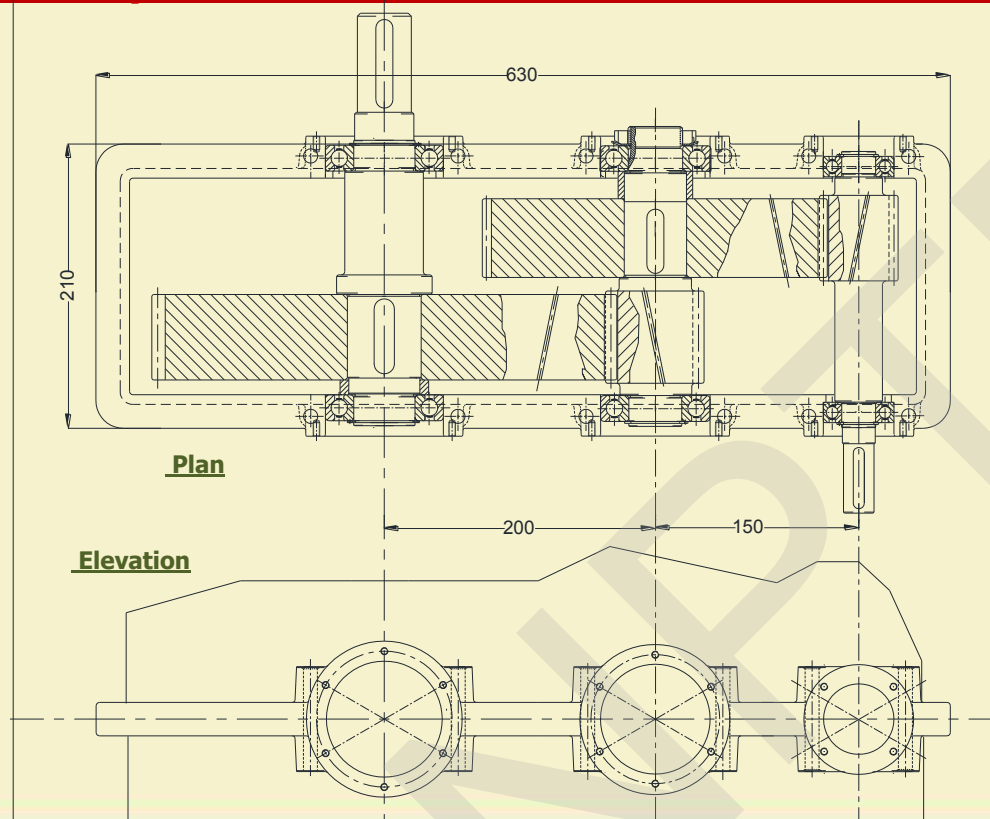
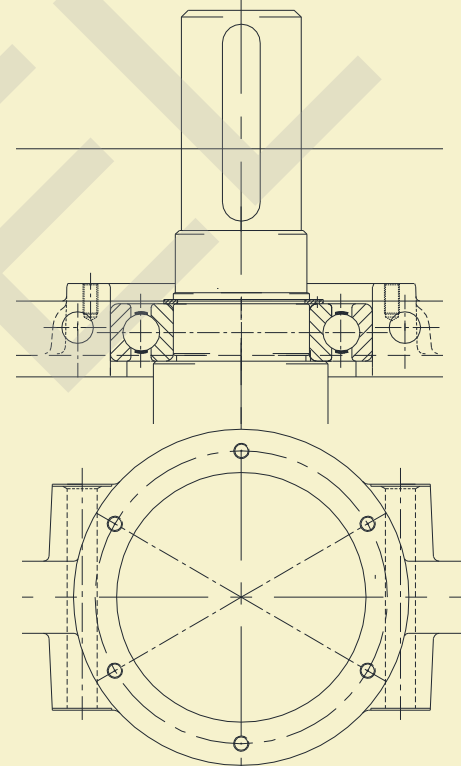
ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



ALL DIMENSIONS ARE IN MM
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Thank You



Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

Lecture-29

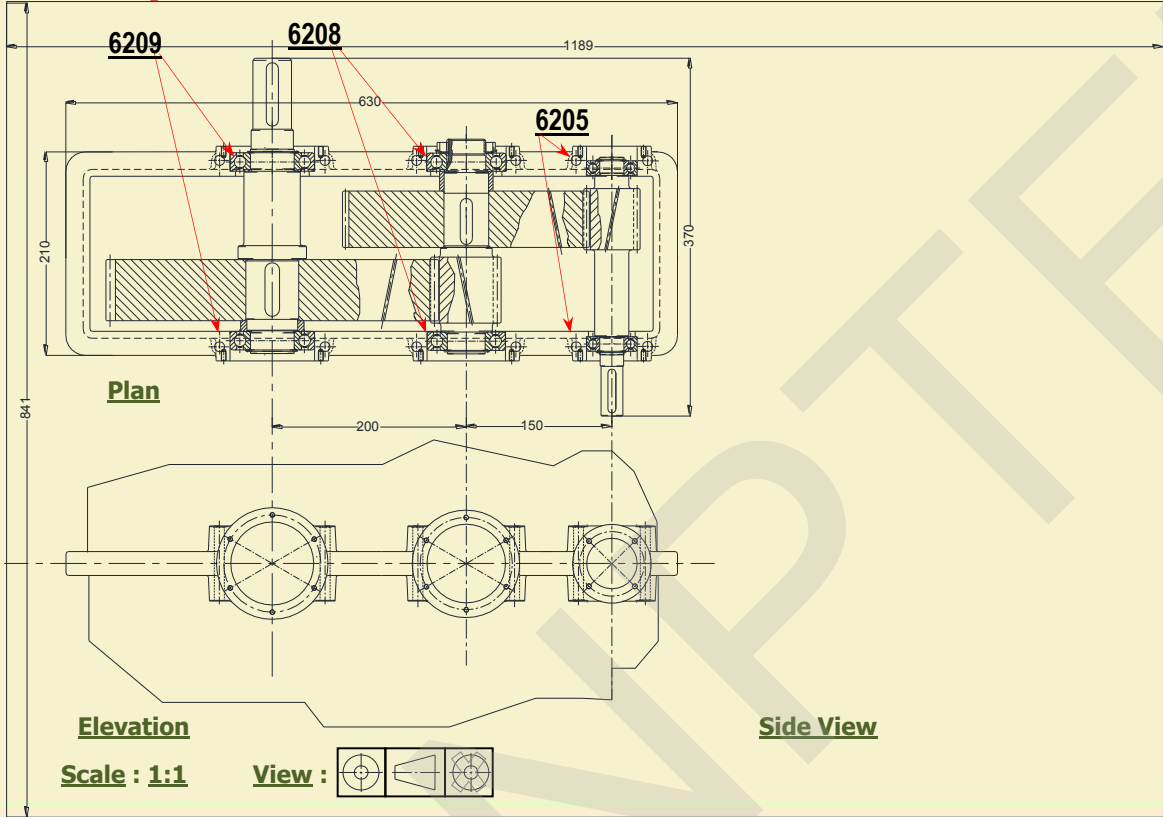
Development of Plan & Elevation of Gear Reduction Unit- II



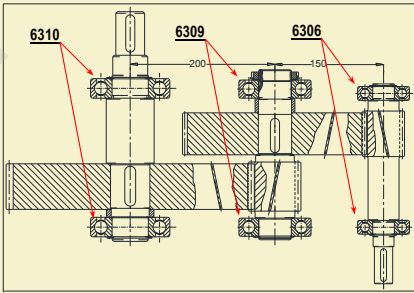
Outline of the Lecture

- **Development of Plan and Elevation of the Reduction Gear Unit- II**
 - **More details of Housing comprising:**
 - **Machining of Housing- Essential Steps**
 - **Bearing Housing,**
 - **Bearing End Cover (Blind),**
 - **Bearing End Covers- with Sealing, at Input and Output,**

Development of Plan and Elevation of Assembled Gear Reduction Unit (Recapitulation) :



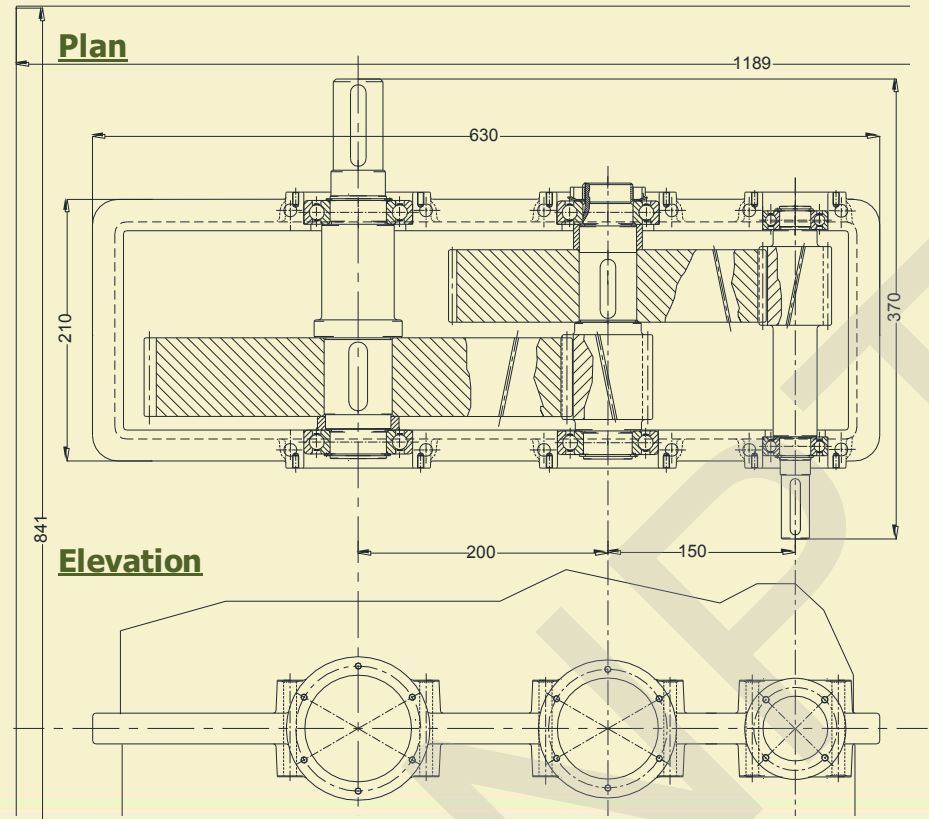
Sheet (A0) Size
1189x841



Plan View

ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



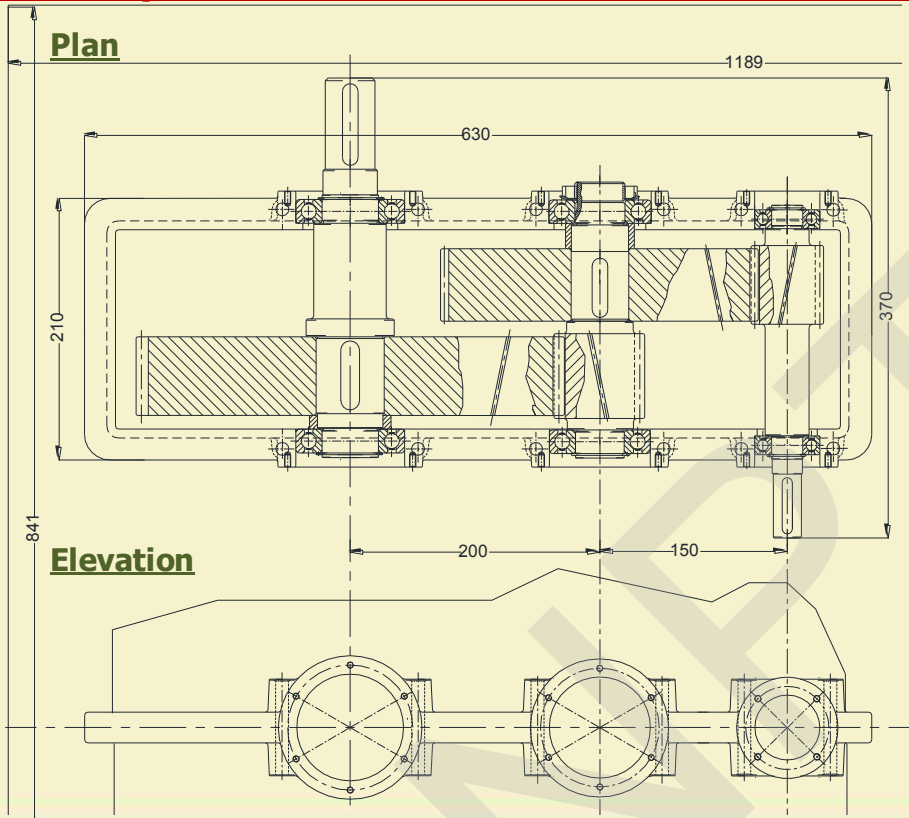
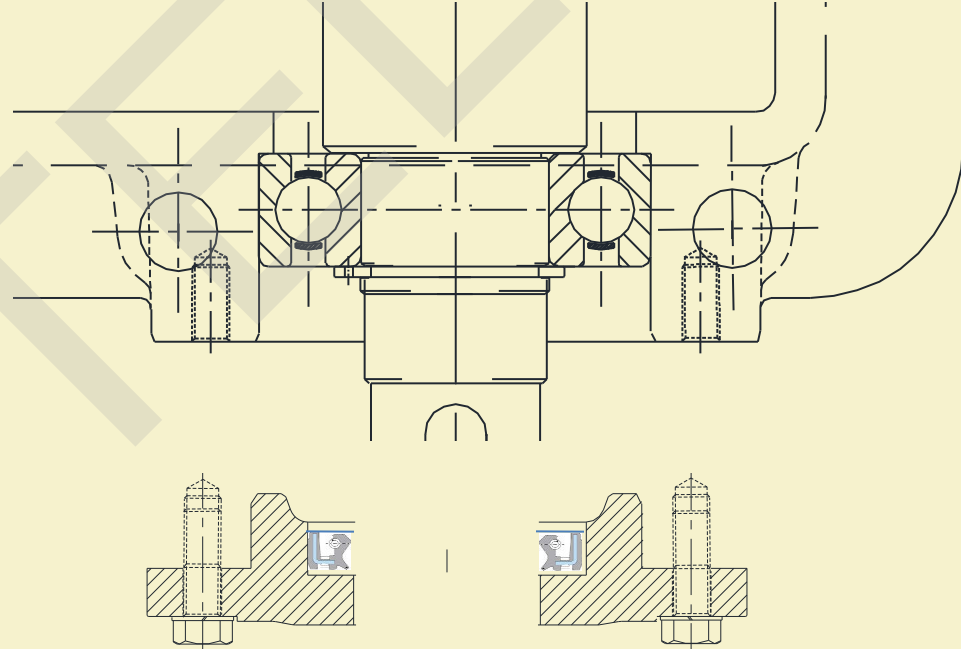
Process- Machining of Housing:



Scale : 1:1 View :

ALL DIMENSIONS ARE IN MM
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Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Input Shaft (Input End)

ALL DIMENSIONS ARE IN MM
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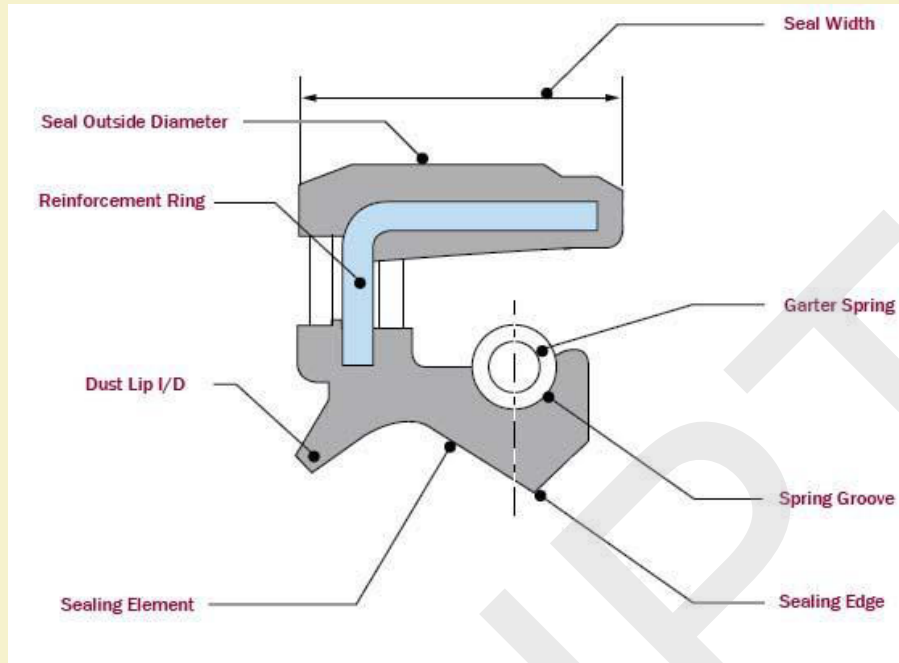
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Prof. Rathindranath Maiti
Mechanical Engineering Department

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Seal Sizes

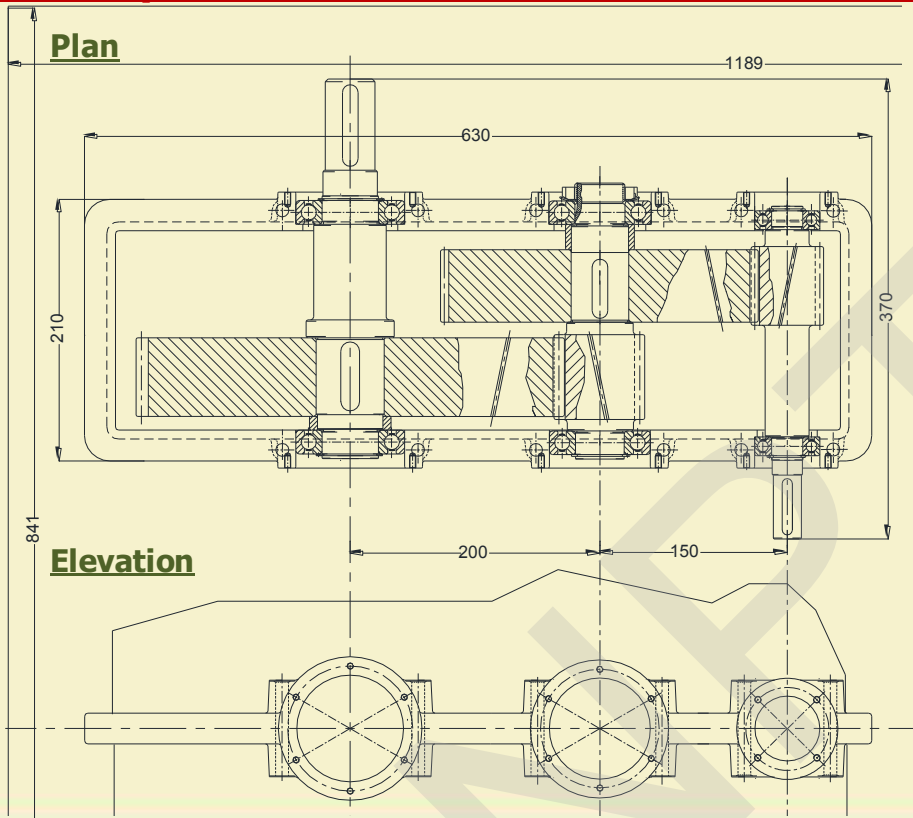
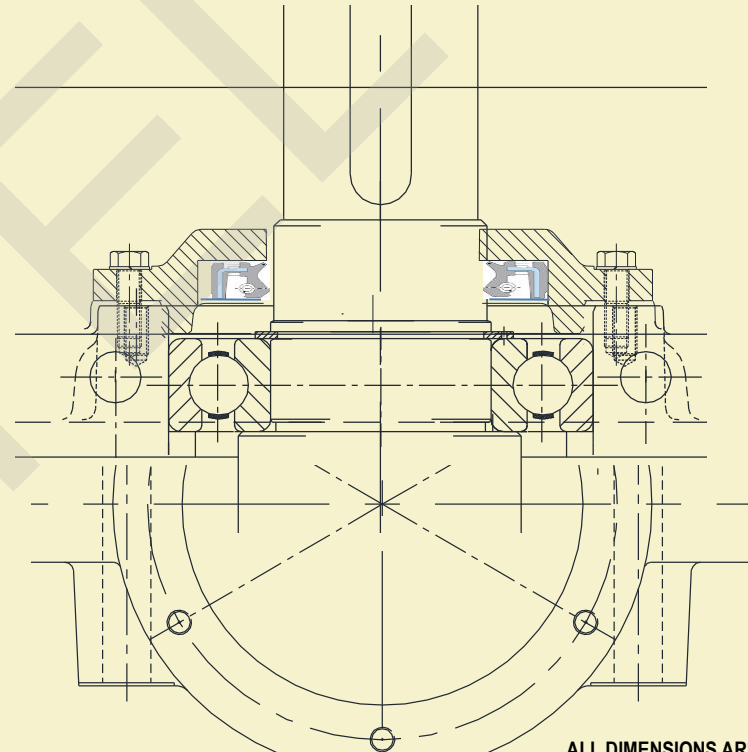
42X68X8

42x72x8

22x35x7

24x37x7

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Output Shaft (Output End)

ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED



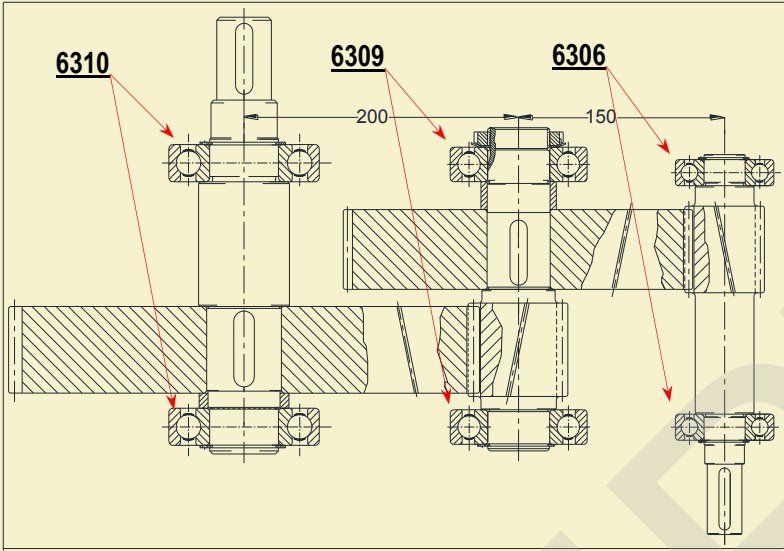
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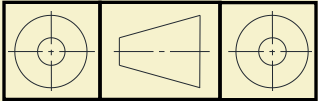
Development of Plan and Elevation of Assembled Gear Reduction Unit (Recapitulation):



Plan View of the Reduction Gear unit
(Only subassemblies of three shafts)
(in the plane of slide)

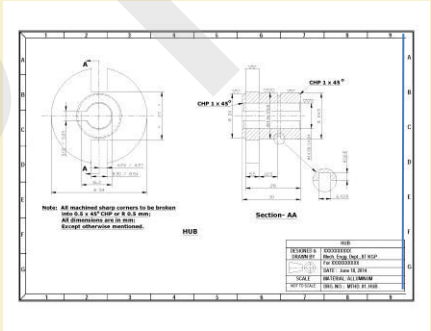
	Milimeter		Inches	
	Height	Width	Height	Width
A0	1189	841	46.8	33.1
A1	841	594	33.1	23.4
A2	594	420	23.4	16.5
A3	420	297	16.5	11.7
A4	297	210	11.7	8.3
A5	210	148	8.3	5.8
A6	148	105	5.8	4.1
A7	105	74	4.1	2.9
A8	74	52	2.9	2.1

Standard Drawing Sheet Sizes



Angle of Projection

Scale : 1:1, 1:2, 1:2.5, 1:5, 1:10



Typical Drawing

ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

..... to be continued.....

Thank You



Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

Lecture-30

Development of Plan & Elevation of Gear Reduction Unit- III

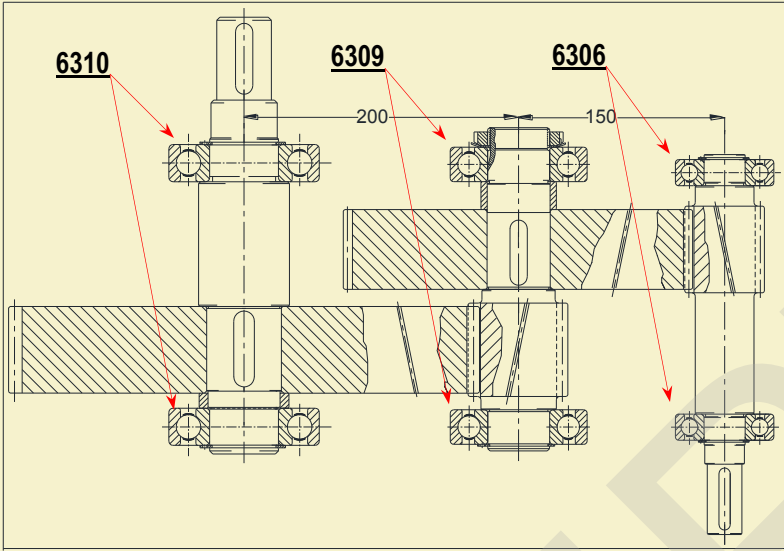


Outline of the Lecture

- **Development of Plan and Elevation of the Reduction Gear Unit- III**
 - **More details of Housing comprising:**
 - **Full Plan View**
 - **Full Elevation**
 - **Side View**
 - **Some important details of the housing**



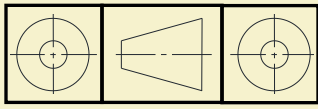
Development of Plan and Elevation of Assembled Gear Reduction Unit (Recapitulation):



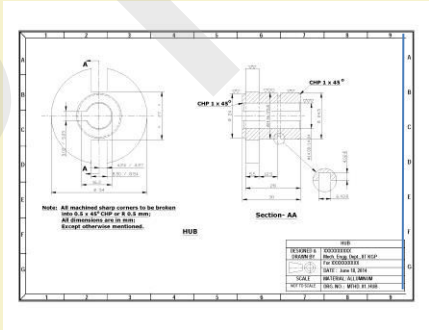
Plan View of the Reduction Gear unit
(Only subassemblies of three shafts)
(in the plane of slide)

	Milimeter		Inches	
	Height	Width	Height	Width
A0	1189	841	46.8	33.1
A1	841	594	33.1	23.4
A2	594	420	23.4	16.5
A3	420	297	16.5	11.7
A4	297	210	11.7	8.3
A5	210	148	8.3	5.8
A6	148	105	5.8	4.1
A7	105	74	4.1	2.9
A8	74	52	2.9	2.1

Standard Drawing Sheet Sizes



Angle of Projection

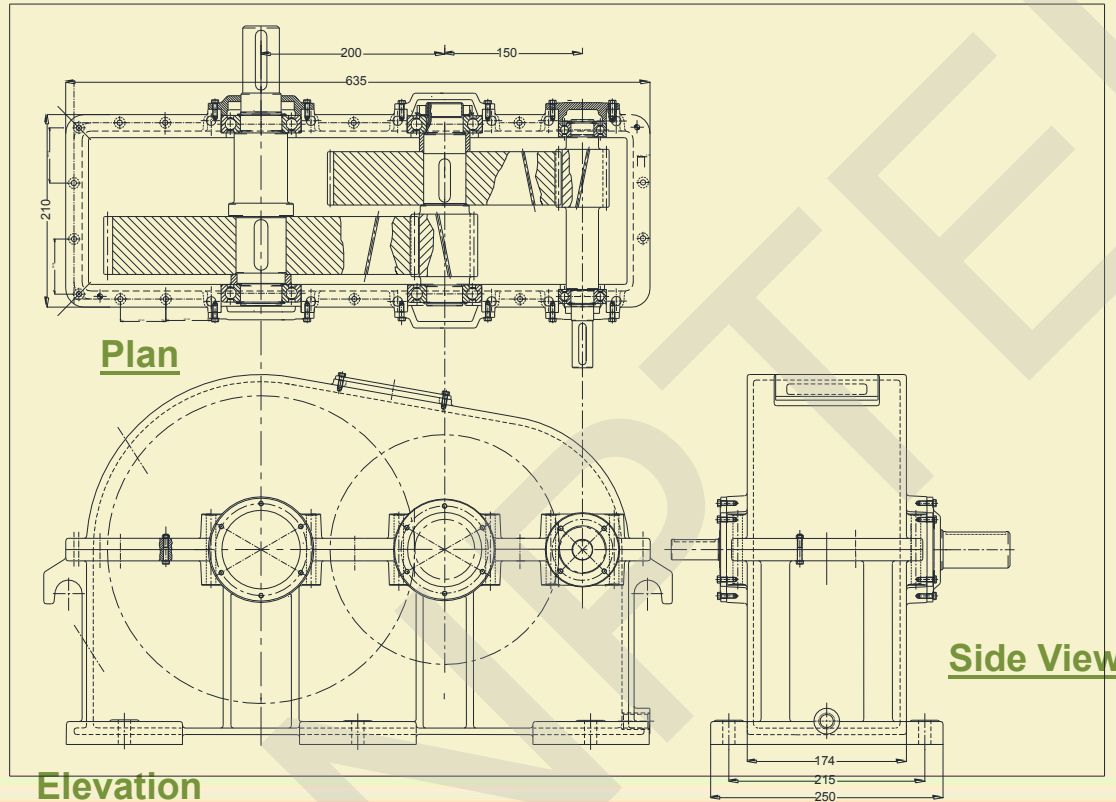


Typical Drawing

Scale : 1:1, 1:2, 1:2.5, 1:5, 1:10

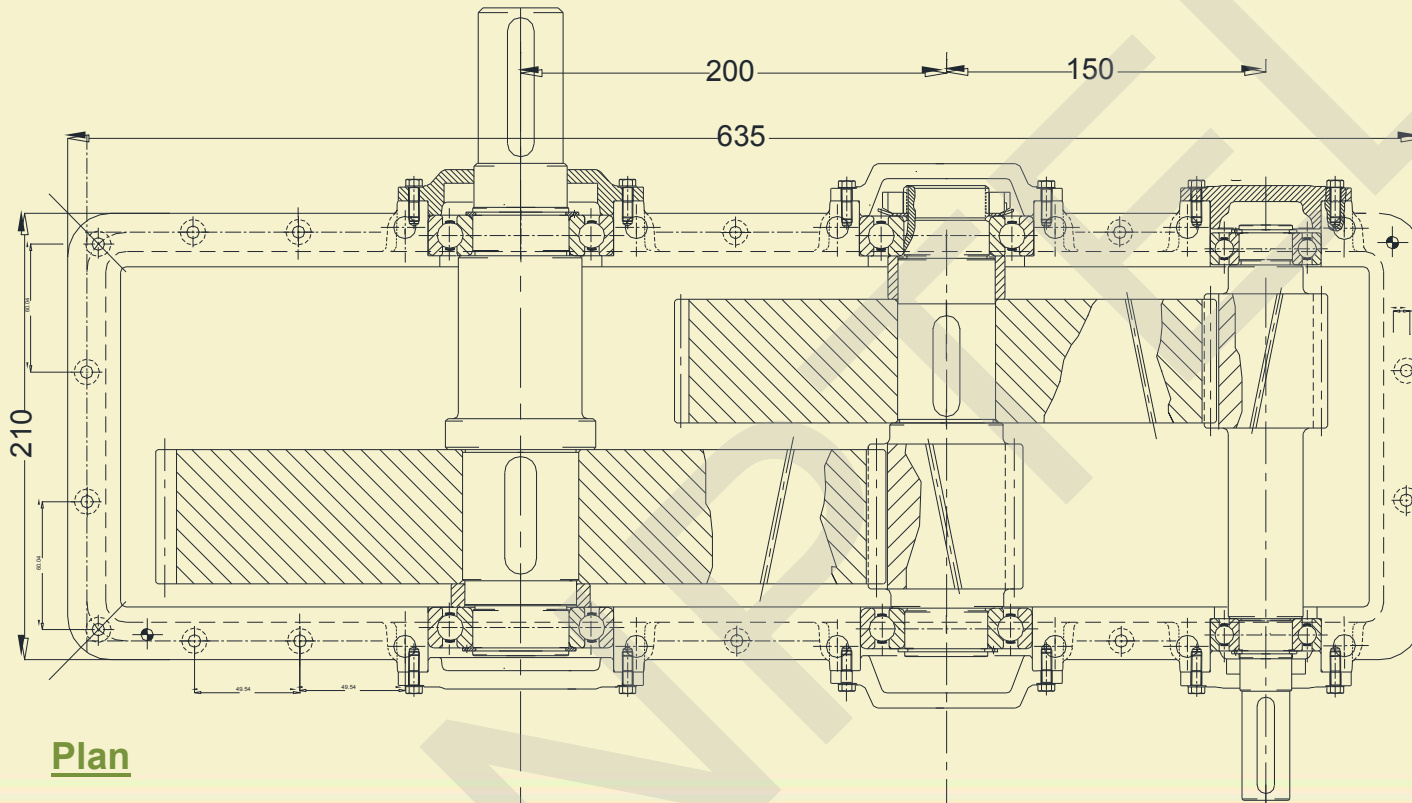
ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :

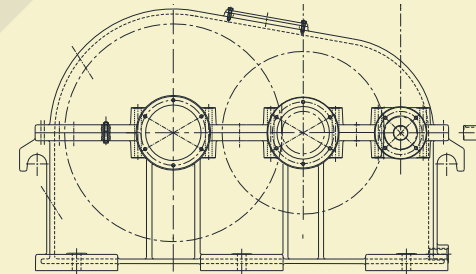


ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

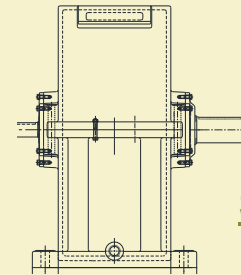
Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Plan



Elevation

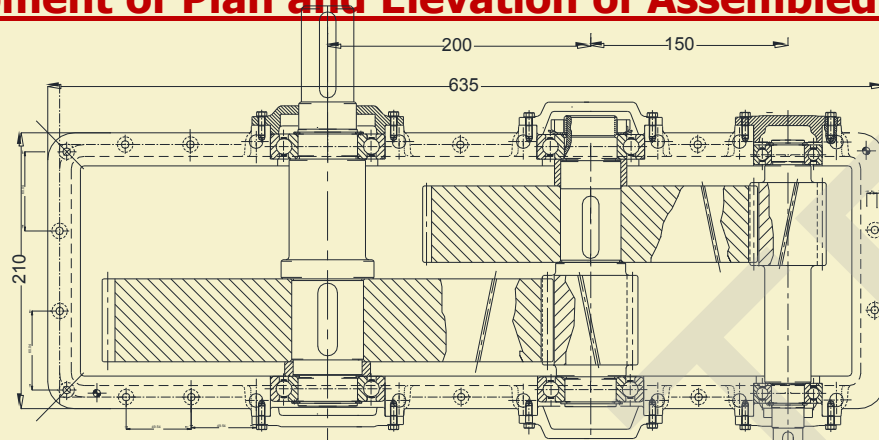


Side View

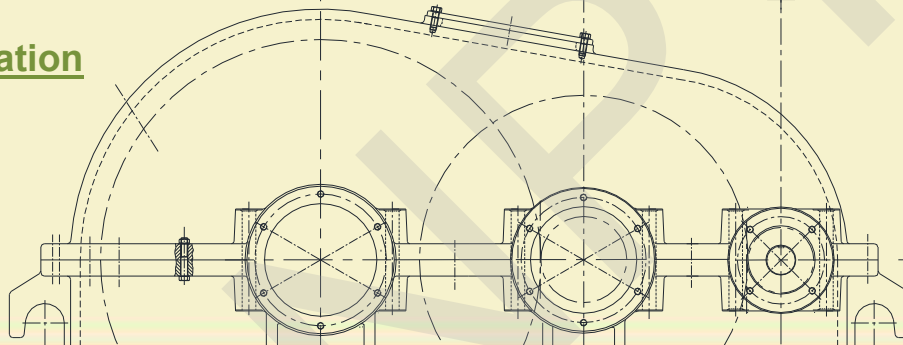
ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :

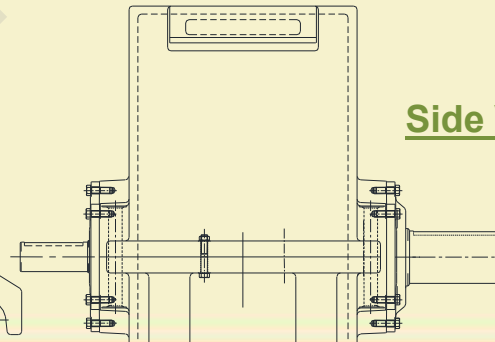
Plan



Elevation

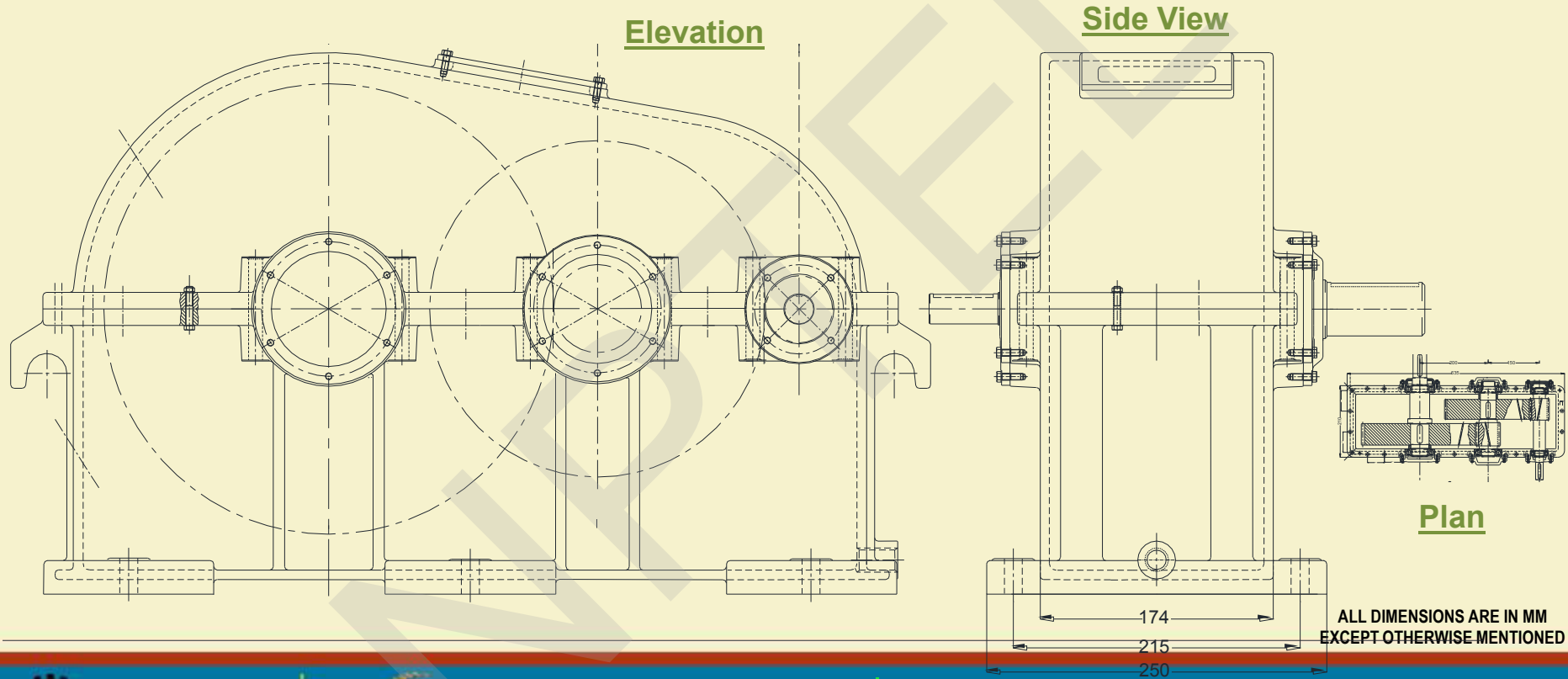


Side View



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Development of Plan and Elevation of Assembled Gear Reduction Unit (Contd...) :



Thank You



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Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

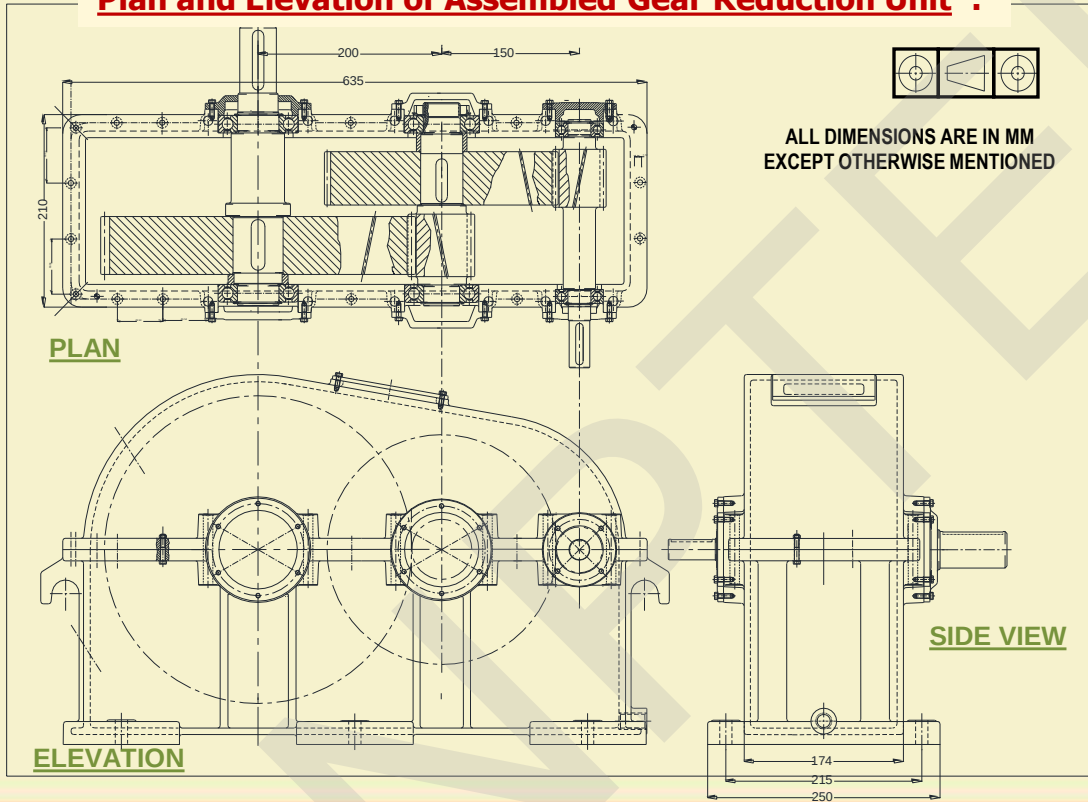
Lecture-31

Detail Drawing of Intermediate Shaft & First stage Gear

Outline of the Lecture

- **Recapitulation on Developed Plan, Elevation and Side Views of the Reduction Gear Unit**
 - **Detail Drawing of Intermediate Shaft
(Including Integral Second Stage Pinion)**
 - **Detail Drawing of 1st. Stage Gear**

Plan and Elevation of Assembled Gear Reduction Unit :



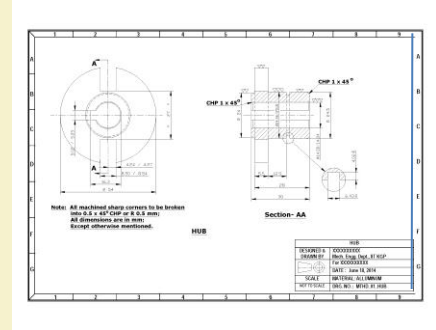
Typical Drawing

Scale : 1:1

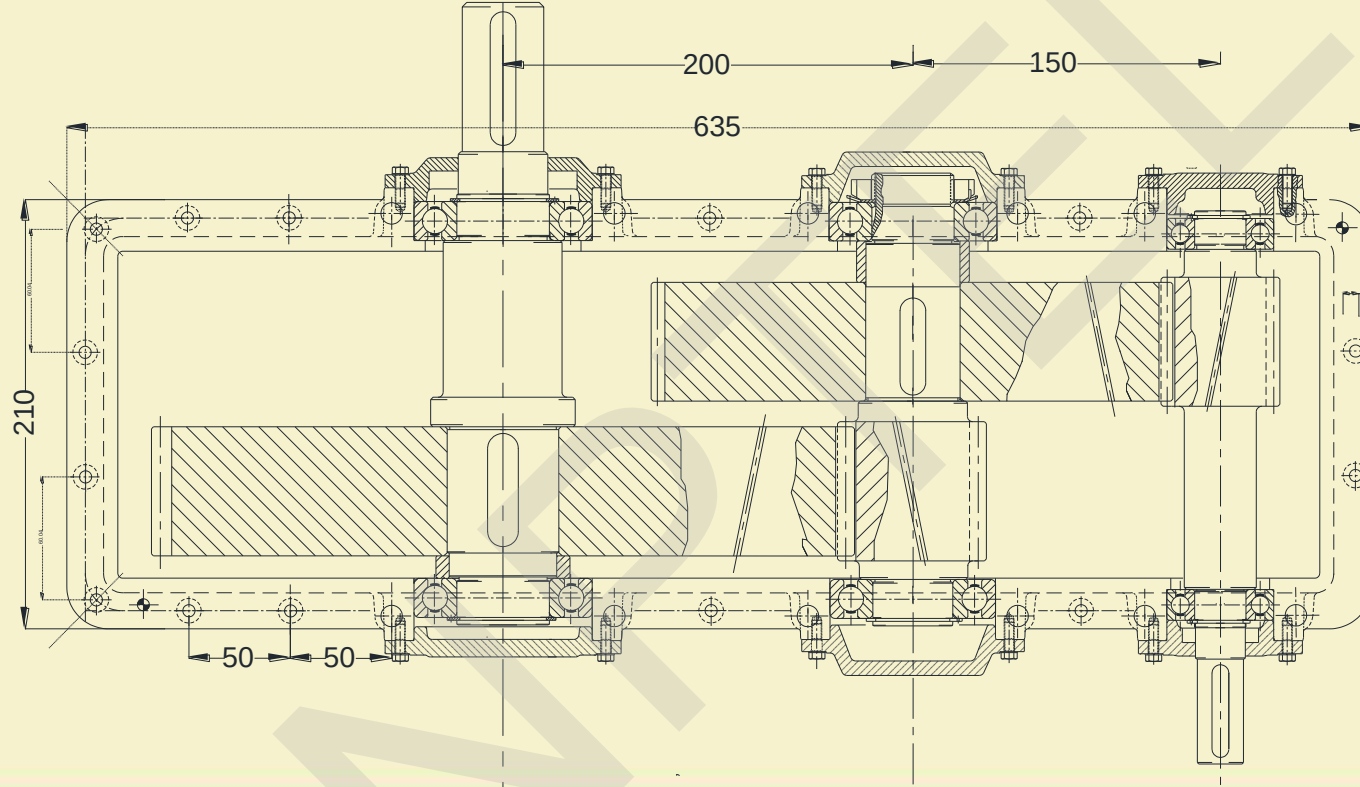
Angle of Projection



**ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED**



Plan View of the Reduction Gear Unit (contd....) :

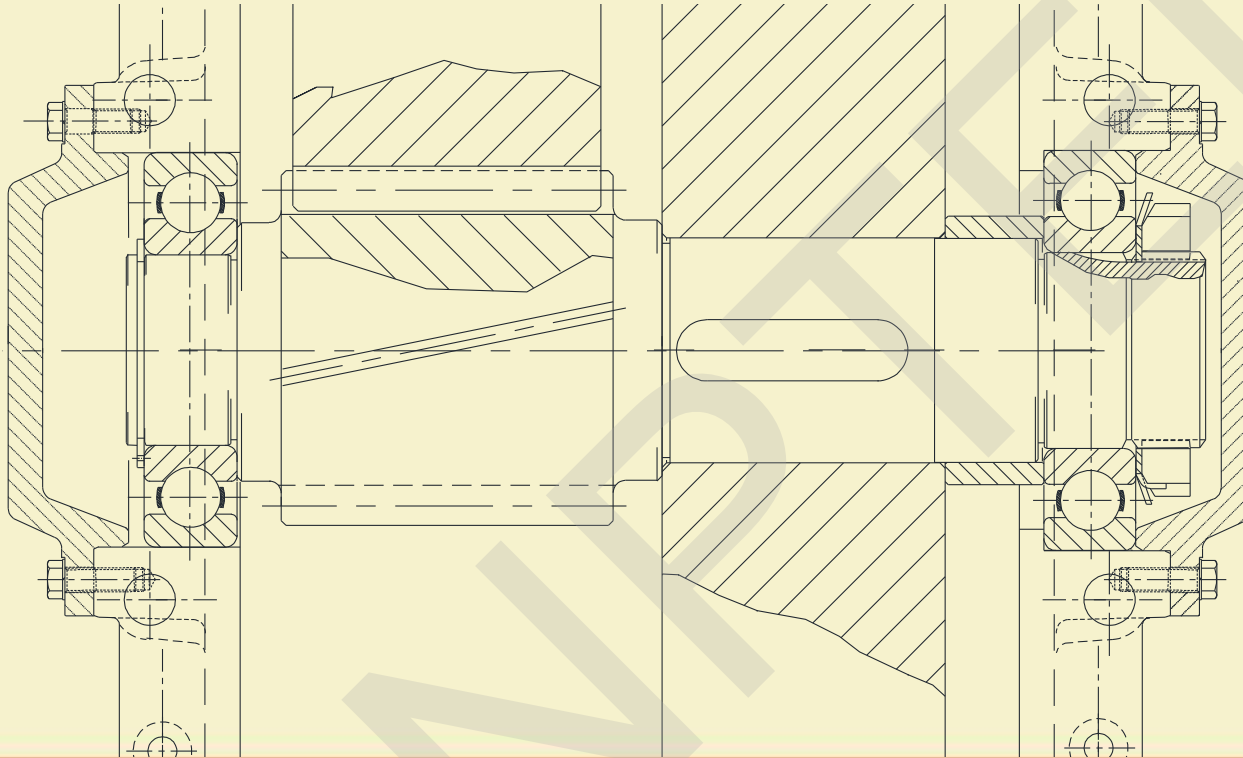


Scale : 1:1
Angle of Projection

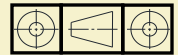


ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Intermediate Shaft with Integral 2nd. Stage Pinion :



Scale : 1:1
Angle of Projection



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Dimensions of Gears and Gear Data Table : (Recapitulation):

The Gear Unit design problem is same as already considered. All data remain same except the Second stage reduction ratio is reduced to 5.125. Overall transmission ratio is now 24.42.

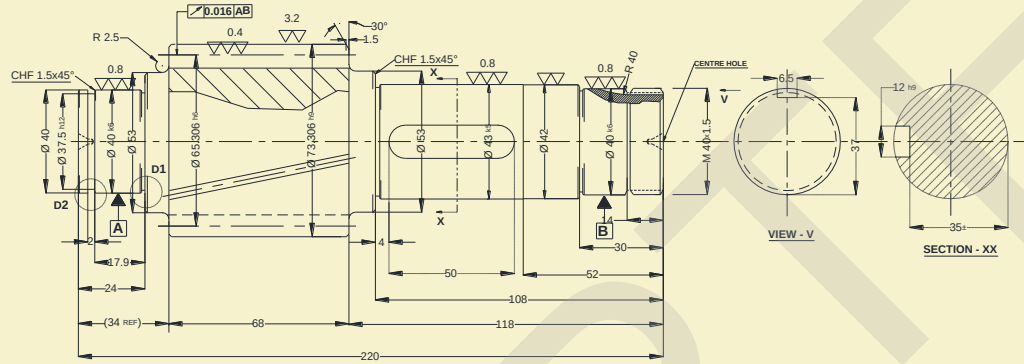
Sl. No.	Description	1 st . Stage		2 nd . Stage	
		Pinion	Gear	Pinion	Gear
1.	Number of Teeth (Z)	17	81	16	82
2.	Tooth Profile	20° Full Depth Involute, Uncorrected			
3.	Normal Module (m_n)	3 mm		4 mm	
4.	Helix Angle (β) and Direction of Helix	11°28'42"		11°28'42"	
		RH	LH	LH	RH
5.	Addendum Height, ($a_f \times m_n = 1 \times m_n$)	3 mm		4 mm	
6.	Dedendum Height, ($d_f \times m_n = 1.25 \times m_n$)	3.75 mm		5 mm	

Dimensions of Gears and Gear data Table : (Recapitulation):

Sl. No.	Description	1 st . Stage		2 nd . Stage	
		Pinion	Gear	Pinion	Gear
7.	Pitch Circle Diameter (mm)	52.04	247.96	65.306	334.694
8.	Centre Distance (mm)	150		200	
9.	Addendum or Tip Circle Diameter (mm)	58.04	253.96	73.306	342.694
10.	Dedendum or Root Circle Diameter (mm)	44.54	240.46	55.306	324.694
11.	Face width (b)	63 mm	58 mm	68 mm	63 mm
12.	Material	EN 19A	EN 18A	EN 19A	EN 18A
13.	Hardness , Through Hardened (BHN)	350	300	350	300

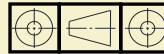
Detail Drawing of Intermediate Shaft with Integral 2nd. Stage Pinion :

A3 Size Drawing Sheet is Chosen for Detail Drawing in 1:1 Scale.

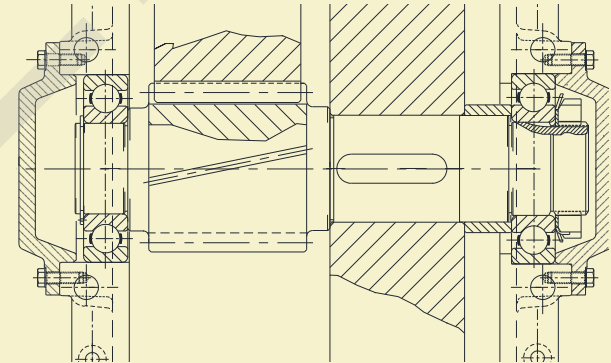


Scale : 1:1

Angle of Projection

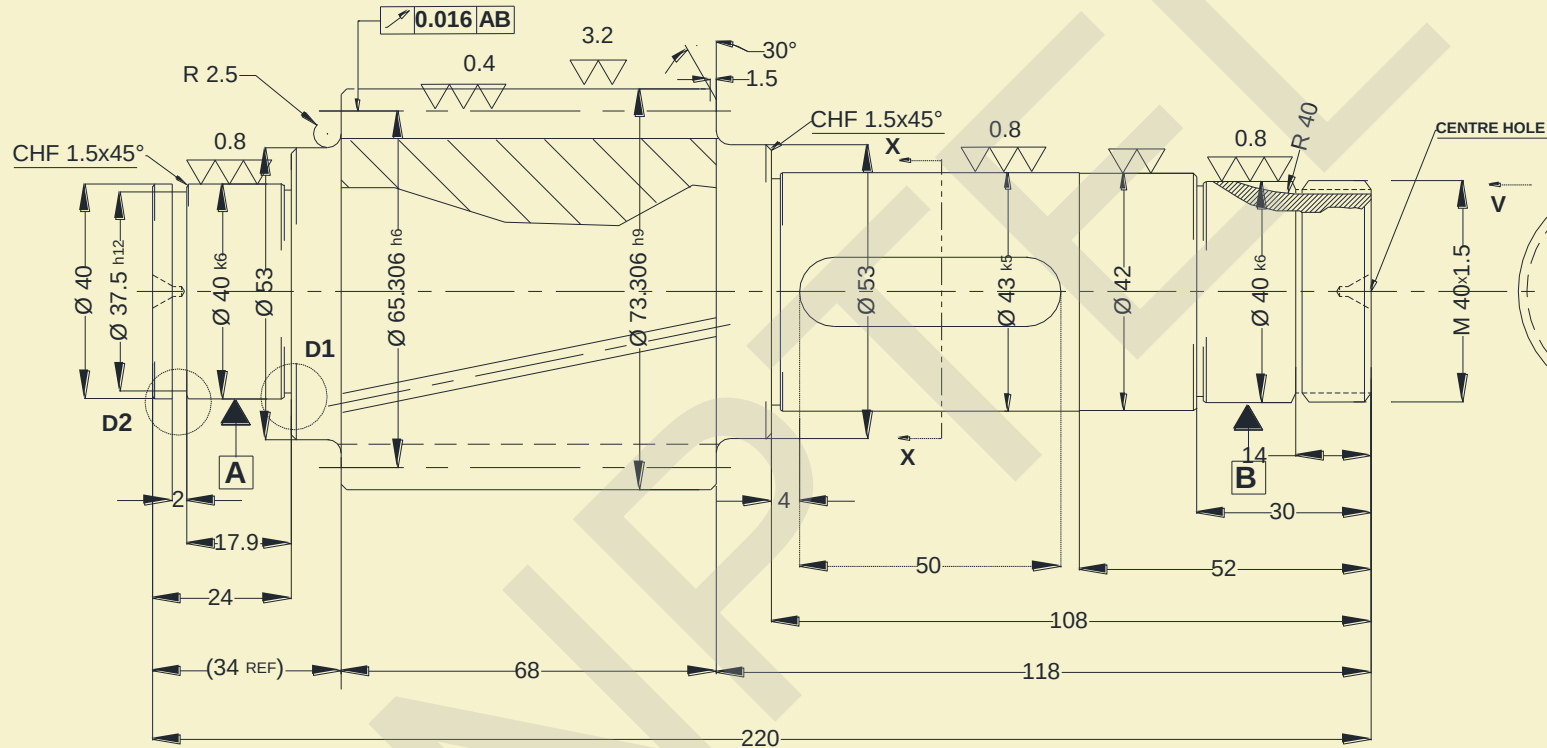


**ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED**



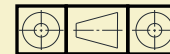
- NOTE :**
1. ALL CORNERS (EDGES) CHAMFER (CHF) IS 1.5 x 45° FOR SHAFT DIA OVER & INCLUDING 50 mm, AND 1 x 45° FOR SHAFT DIA BELOW 50 mm, EXCEPT OTHERWISE MENTIONED.
 2. ALL SHARP CORNERS (EDGES) NOT SHOWN WITH CHF IS BROKEN WITH EITHER 0.5 x 45° CHF OR 0.5 mm RADIUS.
 3. ALL CORNERS IN STEPS HAVE 0.5 mm RADIUS EXCEPT OTHERWISE MENTIONED.
 4. ALL DIMENSIONS AND SURFACES ARE FINISHED WITH GENERAL TOLERANCES EXCEPT OTHERWISE MENTIONED.
 5. ALL DIMENSIONS ARE IN mm EXCEPT OTHERWISE MENTIONED.

Detail Drawing of Intermediate Shaft with Integral 2nd. Stage Pinion (contd....) :



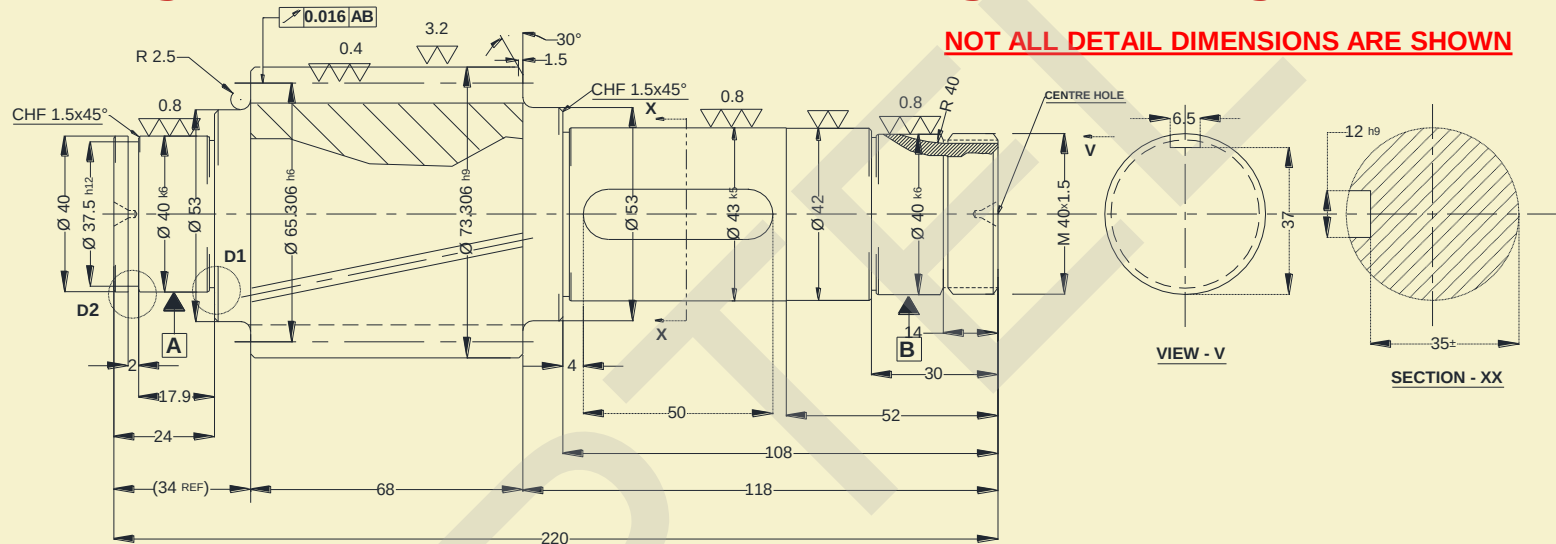
Scale : 1:1

Angle of Projection



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

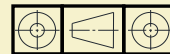
Detail Drawing of Intermediate Shaft with Integral 2nd. Stage Pinion (contd....) :



- NOTE :**
1. ALL CORNERS (EDGES) CHAMFER (CHF) IS 1.5 x 45° FOR SHAFT DIA OVER & INCLUDING 50 mm, AND 1 x 45° FOR SHAFT DIA BELOW 50 mm, EXCEPT OTHERWISE MENTIONED.
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 5. ALL DIMENSIONS ARE IN mm EXCEPT OTHERWISE MENTIONED.

Scale : 1:1

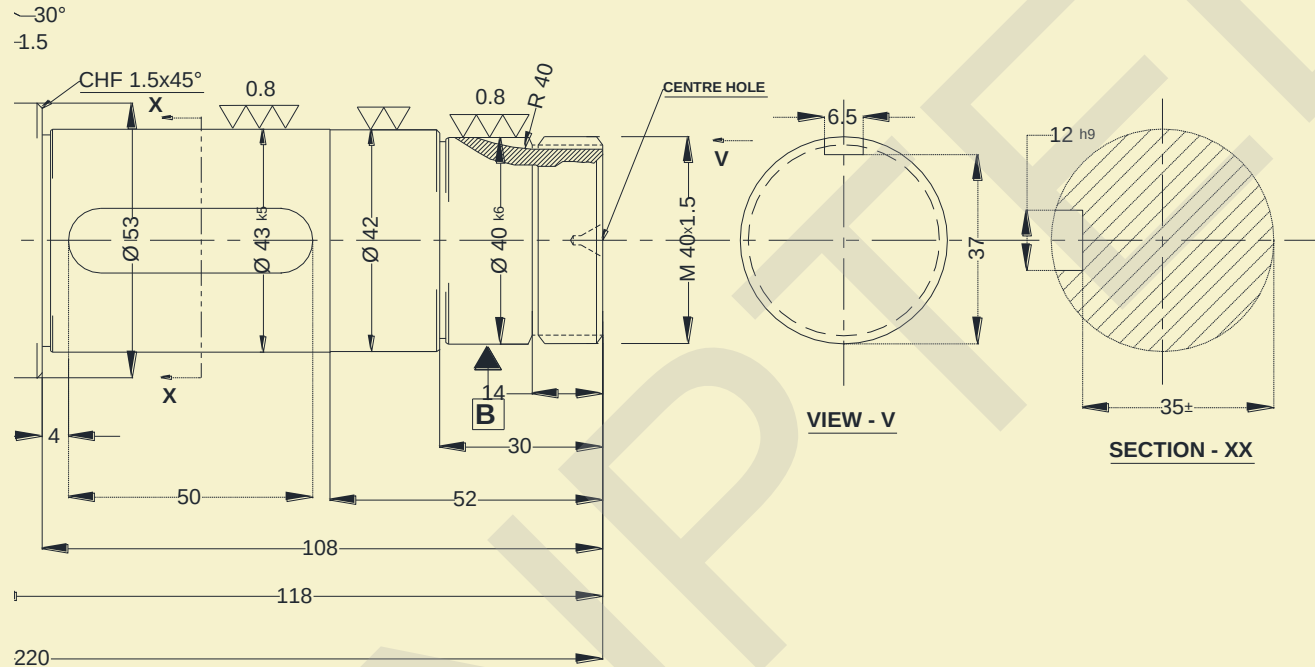
Angle of Projection



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Detail Drawing of Intermediate Shaft with Integral 2nd. Stage Pinion (contd....) :

Details of Key way , Groove for Lock washer and Thread for Lock Nut



NOT ALL DETAIL DIMENSIONS ARE SHOWN

Scale : 1:1
Angle of Projection

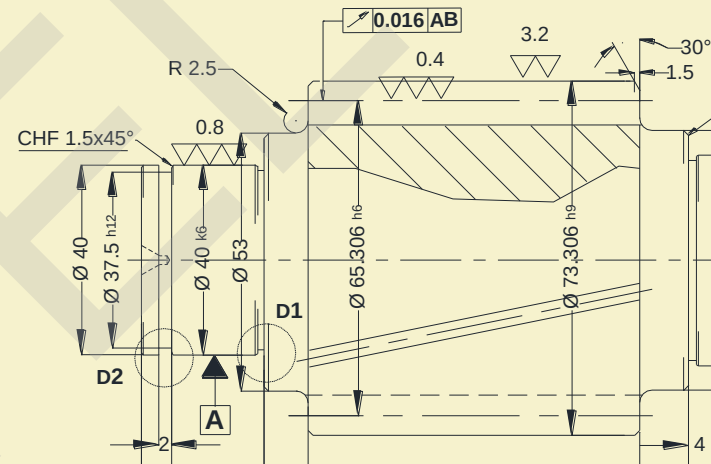


ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

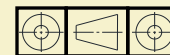
Detail Drawing of Intermediate Shaft with Integral 2nd. Stage Pinion (contd....) :

Details of Pinion

Sl. No.	Description	1 st . Stage		2 nd . Stage	
		Pinion	Gear	Pinion	Gear
1.	Number of Teeth (Z)	17	81	16	82
2.	Tooth Profile	20° Full Depth Involute, Uncorrected			
3.	Normal Module (m_n)	3 mm		4 mm	
4.	Helix Angle (β) and Direction of Helix	11°28'42"		11°28'42"	
		RH	LH	LH	RH
5.	Addendum Height, ($a_f \times m_n = 1 \times m_n$)	3 mm		4 mm	
6.	Dedendum Height, ($d_f \times m_n = 1.25 \times m_n$)	3.75 mm		5 mm	
7.	Pitch Circle Diameter (mm)	52.04	247.96	65.306	334.694
8.	Centre Distance (mm)	150		200	
9.	Addendum or Tip Circle Diameter (mm)	58.04	253.96	73.306	342.694
10.	Dedendum or Root Circle Diameter (mm)	44.54	240.46	55.306	324.694
11.	Face width (b)	63 mm	58 mm	68 mm	63 mm
12.	Material	EN 19A	EN 18A	EN 19A	EN 18A
13.	Hardness , Through Hardened (BHN)	350	300	350	300



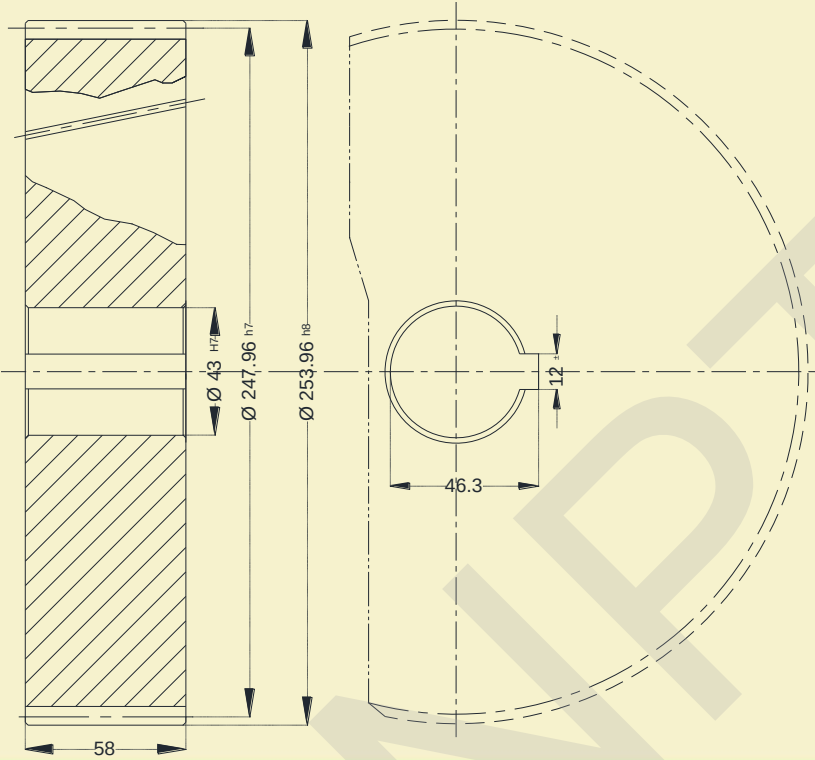
Scale : 1:1
Angle of Projection



ALL DIMENSIONS ARE IN MM
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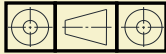
NOT ALL DETAIL DIMENSIONS ARE SHOWN

Detail Drawing 1st. Stage Gear :



Sl. No.	Description	1 st . Stage		2 nd . Stage	
		Pinion	Gear	Pinion	Gear
1.	Number of Teeth (Z)	17	81	16	82
2.	Tooth Profile	20° Full Depth Involute, Uncorrected			
3.	Normal Module (m_n)	3 mm		4 mm	
4.	Helix Angle (β) and Direction of Helix	11°28'42"		11°28'42"	
		RH	LH	LH	RH
5.	Addendum Height, ($a_f \times m_n = 1 \times m_n$)	3 mm		4 mm	
6.	Dedendum Height, ($d_f \times m_n = 1.25 \times m_n$)	3.75 mm		5 mm	
7.	Pitch Circle Diameter (mm)	52.04	247.96	65.306	334.694
8.	Centre Distance (mm)	150		200	
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11.	Face width (b)	63 mm	58 mm	68 mm	63 mm
12.	Material	EN 19A	EN 18A	EN 19A	EN 18A
13.	Hardness , Through Hardened (BHN)	350	300	350	300

Scale : 1:1
Angle of Projection



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

NOT ALL DETAIL DIMENSIONS ARE SHOWN

Thank You



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Mechanical Engineering Department

Module-06

Design of a General Purpose Industrial Helical Gear Reduction Unit- Part IV

Lecture-32

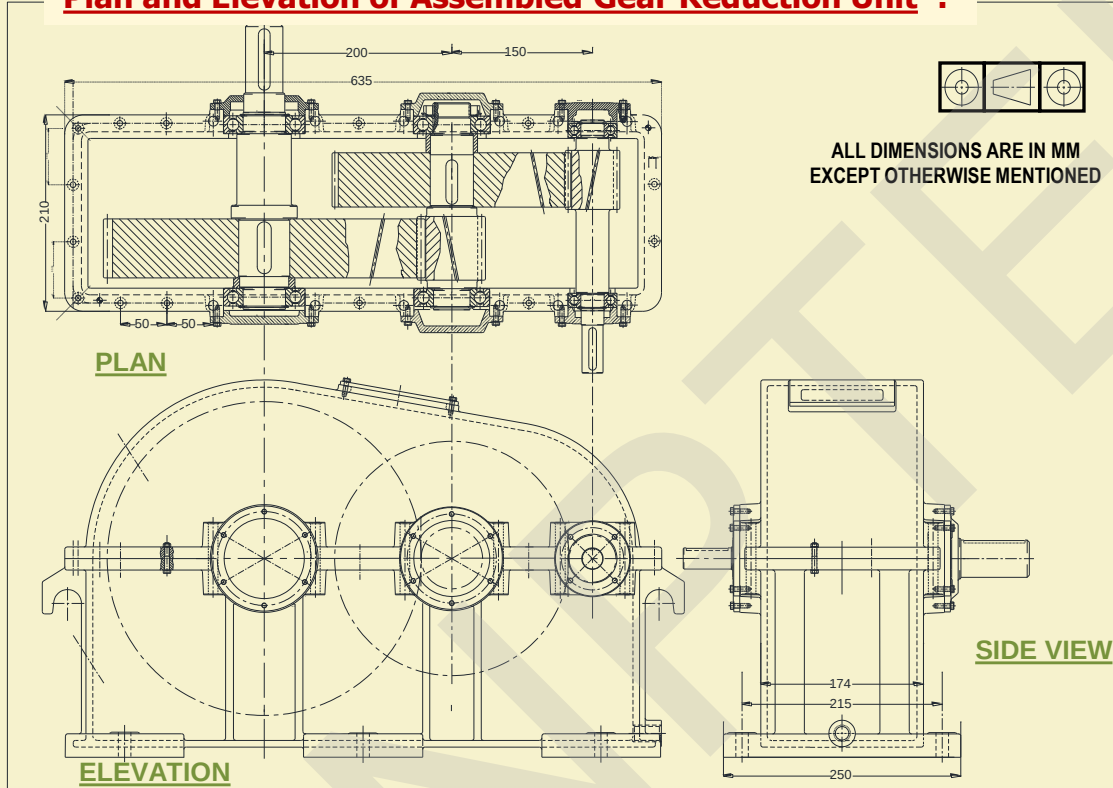
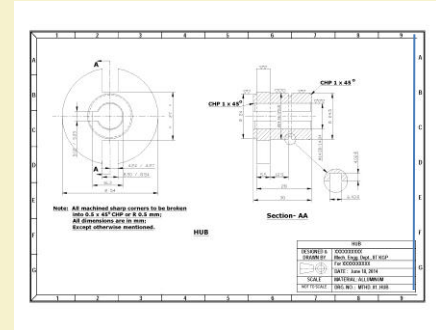
Concluding Remarks on Conventional Gear and Gear Unit Design



Outline of the Lecture

- Plan, Elevation and Side Views of the Designed Reduction Gear Unit
- Concluding Remarks on Conventional Gear and Gear Unit Design

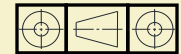
Plan and Elevation of Assembled Gear Reduction Unit :



Typical Drawing

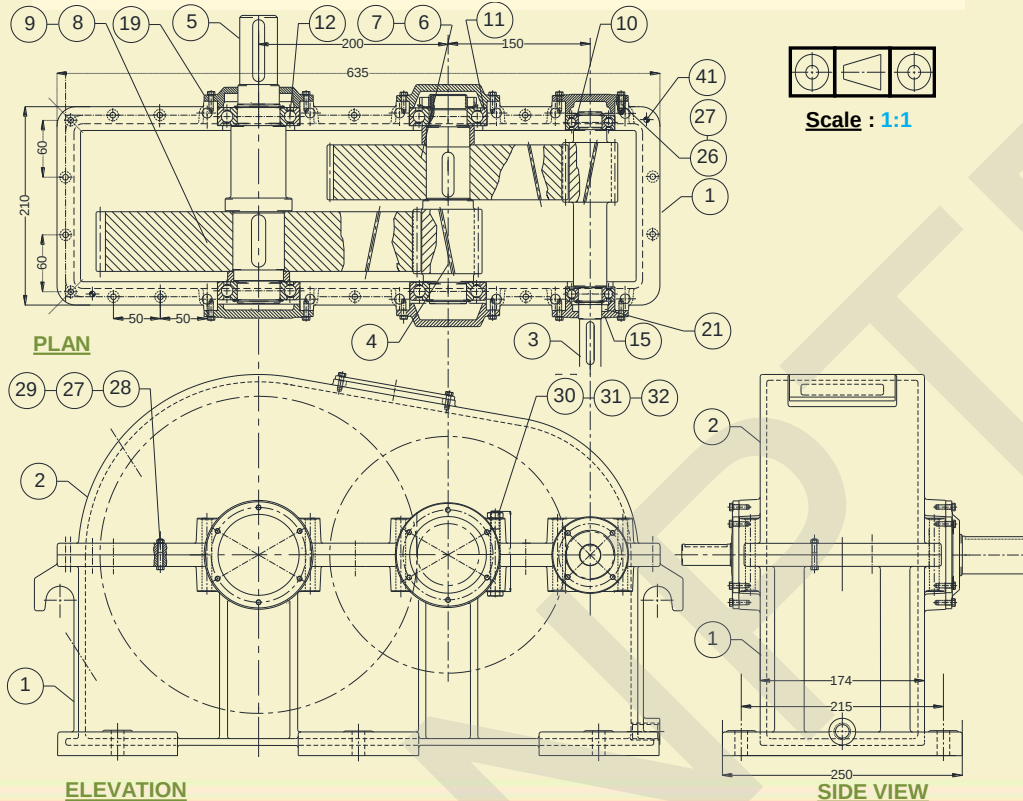
Scale : 1:1

Angle of Projection



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Plan and Elevation of Assembled Gear Reduction Unit :



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

41.		DOWEL PIN	2	C40	
32.		NUT (HEX HEAD)	12		M10
31.		SPRING WASHER	24		M10 (IS : 3063)
30.		BOLT (HEX HEAD)	12		M10x1.5x85 (IS : 2389)
29.		NUT (HEX HEAD)	14		M5
28.		BOLT (HEX HEAD)	14		M5x0.8x30
27.		SPRING WASHER	60		M5 (IS : 3063)
26.		BOLT (HEX HEAD)	32		M5x0.8x15 (IS : 2389)
21.		OIL SEAL	1		24x37x7 C (IS : 5129)
19.		BEARING COVER	1	CI	
15.		BEARING COVER	1	CI	
12.		BALL BEARING	2		SKF 6208
11.		BALL BEARING	2		SKF 6207
10.		BALL BEARING	2		SKF 6205
9.		PARALLEL KEY (ROUND HEAD)	1	C40	16x10x55 (IS : 2710)
8.		2 ND . STAGE GEAR	1	EN 18 (40Cr1)	(PHHT)
7.		PARALLEL KEY (ROUND HEAD)	1	C20	14x9x50 (IS : 2710)
6.		1 ST . STAGE GEAR	1	EN 18 (40Cr1)	(PHHT)
5.		OUTPUT SHAFT	1	C45	
4.		INTERMEDIATE SHAFT	1	EN 19 (40Cr4Mo3)	PRE HOBBING HEAT
3.		INPUT SHAFT	1	EN 19 (40Cr4Mo3)	TREATED (PHHT)
2.		TOP HOUSING	1	CI	
1.		BOTTOM HOUSING	1	CI	
ITEM NO.	PART DRAWING NO.	DESCRIPTION	NO. OFF	MATERIAL	REMARKS / SPECIFICATION

SAMPLE BILL OF MATERIAL

Design Steps (Recapitulation). :

Step-1

➤ **Selection of number of stages for a Total Transmission Ratio** $i_t = i_1 \times i_2 \times \dots$

Step-2

In next step gears are designed:

Module Estimation on Strength Basis:

Input Torque (Nominal):

$$T_i = \frac{\text{Power}}{2\pi\omega_i}$$

$$m_n = \sqrt[3]{\frac{2T\cos\beta}{S_o C_v \psi_{YZ} C_w}}$$

Materials for Pinion , Gear & Shaft

Wear Load Capacity of Teeth Pair

In $F_w = K Q_g d_{pp} b$, Q_g can also be expressed as: $Q_g = \left[\frac{2 Z_g}{Z_p + Z_g} \right]$

Now as $d_{pp} = Z_p m_n$ and $d_{pg} = Z_g m_n$ then F_w can also be expressed as:

$$F_w = K Q_p d_{pg} b \quad \text{Where, } Q_p = \left[\frac{2 Z_p}{Z_p + Z_g} \right]$$

$d_{pg} = d_2$ being the pitch circle diameter of gear.

In case of helical gear,

$$F_w = \frac{K Q_p d_{pg} b}{\cos \beta} = \frac{K Q_g d_{pp} b}{\cos \beta}$$

Where, d_{pg} and d_{pp} are pcd of helical gear and pinion respectively.



Probable Dynamic Load at Tooth Contact

Probable Dynamic Load $F_d = F_n + F_i$

Where, F_i is increase in load over the normal load.

Buckingham proposed a detail expression for F_i considering the accuracy and manufacturing errors in gear.

However, $F_d = \frac{F_n}{C_v}$ and $1.15F_d \leq F_w$ are in common practice for designing ordinary purpose industrial gear unit considering infinite life of gears.

Layout & Preliminary
Bearing Selection (Contd.....)

Step 3 to 5:

Roller Bearings:

15 to 25 mm
(Typical)

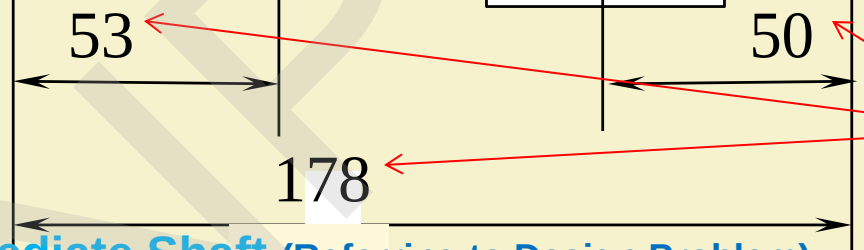
10 to 15 mm (Typical)

15 to 25 mm
(Typical)

(Not taper roller
in this case).

Considering
bearing widths,

finally distances
are marked.

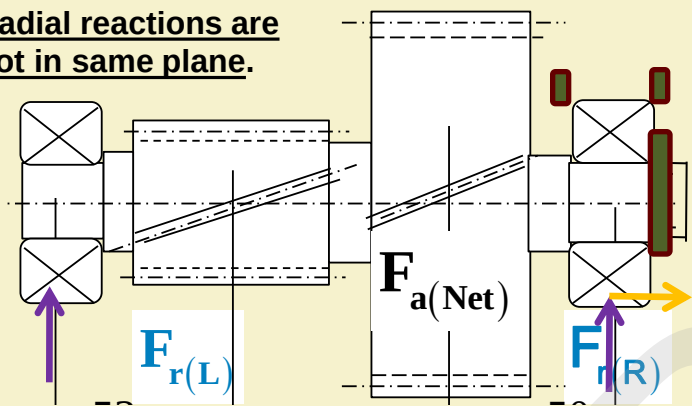


Layout of Intermediate Shaft (Referring to Design Problem)

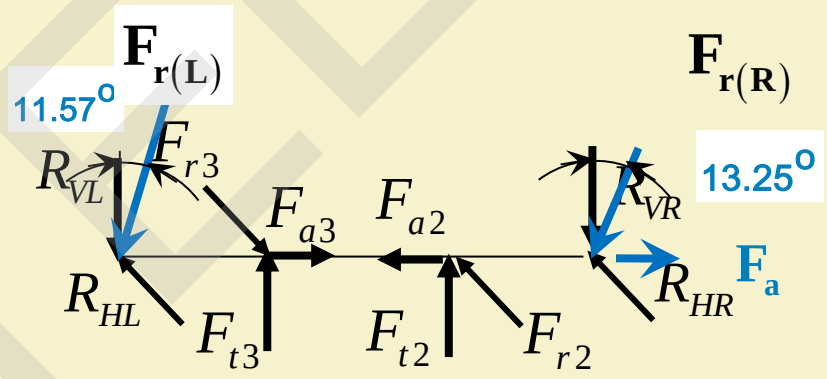
Bearing Life Estimation 5th. Step (Contd...):

The Final bearing reactions:

Radial reactions are not in same plane.



Bearing Reactions (& Locking)



Resultant axial load may act only on one bearing irrespective of its direction (i.e., direction of shaft rotation).

Design Verification of Intermediate Shaft

Step – 6

Verification of Overall factor of safety at Critical Section

Then a factor of safety f_s can be estimated using the following formula, which is based on maximum shear stress theory under combined, bending, torsion and direct normal stresses.

$$\frac{S_y}{f_s} = \sqrt{\left(\sigma_m + k_f \frac{S_y}{S_{en}} \sigma_a \right)^2 + 4\tau_m^2}$$

Where,

S_y = Yield strength of shaft material

S_{en} = Endurance strength of shaft material

σ_m = Mean (average) stress at considered section due to axial load.

σ_a = Maximum alternating stress at considered section due to bending.

τ_m = Maximum shear stress at considered section due to torsion.

k_f = A factor considering the feature of section and severity of service.

It is chosen considering on what basis σ_a has been calculated.

Development of Drawing (Recapitulation). :

Step-7

Layout of Shafts

Subassemblies (Including Bearings) of all Shafts

Step-8

Full Assembly - Plan view with top open

Elevation and Side views

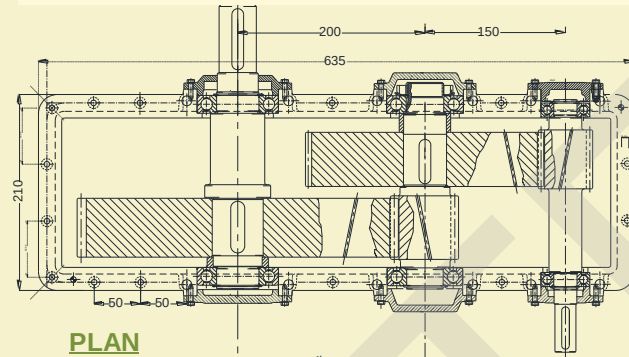
Step-9

Detail Drawings of All components.

Step-10

Bill of Materials and Documentation.

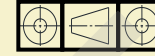
Plan and Elevation of Assembled Gear Reduction Unit :



PLAN

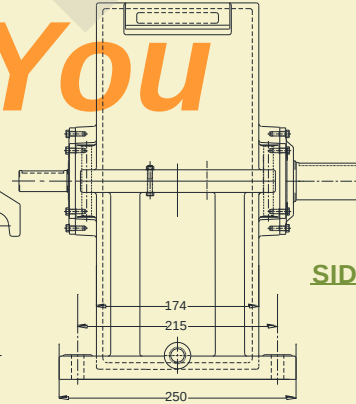


ELEVATION



ALL DIMENSIONS ARE IN MM
EXCEPT OTHERWISE MENTIONED

Scale : 1:1



SIDE VIEW



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CERTIFICATION COURSES

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